# PREPARATION OF ALBERTA ENVIRONMENT REGIONAL AERMOD SCREENING METEOROLOGY DATA SETS

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# FOREWORD

Alberta Environment (AENV) adopted AERMOD as one of its regulatory models according to the Air Quality Model Guideline (October 2000). AENV deemed it necessary to develop representative screening meteorological data sets for each of the six administrative regions within the province of Alberta, to allow for a better and easier use of the AERMOD in Alberta. The screening meteorology data sets are available to the public on the AENV website at http://www3.gov.ab.ca/env.

Alberta Environment contracted URS in July 2000 to prepare representative screening meteorology data sets for AERMOD. Although the meteorological data sets were prepared for AENV's six administrative regions that existed in 2000, the data are still representative of the current three administrative regions.

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# SUMMARY

URS Corporation (URS), on behalf of Alberta Environment (AENV), has prepared six regionally representative screening meteorology data sets using the U.S. EPA AERMET meteorological preprocessor. These meteorological data sets are representative of the six administrative regions established by AENV, within the province of Alberta. The six screening meteorology data sets can specifically be used as meteorological input to the U.S. EPA AERMOD dispersion model. The AERMOD dispersion model is listed as an approved refined air quality assessment model in the AENV 'Air Quality Model Guideline, October 2000' document. AENV is proposing to make the six regionally representative screening meteorology data sets available to the public on their website (http://www3.gov.ab.ca/env), in order to promote and facilitate air quality assessments using the AERMOD dispersion model.

The AERMET meteorological preprocessor requires hourly surface data, twice daily upper air data, and site specific surface characteristic data. For each of the six AENV administrative regions, a single surface meteorological monitoring station, and a single upper air meteorological monitoring station were selected. In the interest of consistency, the six surface meteorology monitoring stations, and the five year data periods, were selected to correspond with the screening meteorology data sets appropriate for the U.S. EPA ISCST3 dispersion model, available on the AENV website. The required upper air meteorology data sets were obtained from upper air monitoring stations located in central Alberta, and northern Montana. The input meteorological data (surface and upper air) was reviewed through a quality control/quality assurance (QA/QC) procedure. These procedures identified missing and calm wind data values, and applied data corrections appropriate for meteorological dispersion model input files. Regionally representative site surface characteristics were assigned based on the dominant vegetation types in each region. The regional vegetation information was gathered from an ecoregion map of Alberta. Finally the AERMET meteorological preprocessor was run using surface, upper air, and site surface characteristic data (for each of the six AENV administrative regions), and the six regional AERMOD input screening meteorology data set were output.

# ACKNOWLEDGEMENTS

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# 1.0 INTRODUCTION

URS Corporation (URS) was retained by Alberta Environment (AENV) to prepare six regional, 5-year screening meteorology data sets (using the U.S. EPA AERMET meteorological preprocessor) appropriate for the U.S. EPA AERMOD dispersion model. The regionally representative screening meteorology data sets were prepared for each of the six AENV administrative regions (Northwest Boreal, Northeast Boreal, Northern East Slopes, Parkland, Bow, and Prairie) depicted in Figure 1.1. The AERMOD dispersion model is listed as an approved refined air quality assessment air quality model in the AENV 'Air Quality Model Guideline, October 2000' document. The availability of these regional meteorology input data sets should facilitate future air quality assessments in Alberta using the AERMOD dispersion model.

A similar project, which yielded six regional screening meteorology input files appropriate for the U.S. EPA ISCST3 dispersion model was executed in 1999. During the project initiation meeting for this project, it was established that in the interest of consistency, the same six surface meteorology monitoring stations (and five-year monitoring periods) selected for 1999 ISCST3 model project, would be used for this project. In addition these discussions concluded that the current project would be best executed using specially formatted surface and upper air meteorological data files available from Environment Canada (as opposed to executing the project utilizing typical Environment Canada data files for each of the required meteorology data elements). These specially formatted surface and upper air meteorology data files (designated CD-144, and TD6201) can be directly read by the AERMET meteorology preprocessor. Project initiation discussions with AENV staff resulted in selecting the input upper air data sets from the Stony Plain, Alberta (for the 4 most northerly regions), and the Great Falls, Montana (for the two most southerly regions) upper air monitoring stations.

The second phase of the project involved analyzing the special surface (CD-144) and upper air (TD6201) AERMET input files from Environment Canada, and applying quality assurance, and quality control procedures to correct any missing, or calm wind data values. Dispersion models like AERMOD are not generally applicable to the prediction of pollutant concentrations under light of calm wind speeds (<1m/s). Therefore the calm wind data values were replaced with a minimum wind speed of 1 m/s, and a randomized wind direction. Randomization was also applied to the input wind direction data, which is received in a format with whole 10-degree sectors. Site surface characteristic data, also required by the AERMET preprocessor, was assigned based on the dominant vegetation types in each AENV administrative region, based on ecoregion maps of Alberta. Finally the AERMET meteorology preprocessor was run for each of the six regionally representative stations, to produce the required input screening meteorology data files for the AERMOD dispersion model. This report summarizes the methodology associated with preparing the six regional screening meteorological data sets appropriate for the AERMOD dispersion model, the QA/QC procedures applied, the site surface characteristic assignment, and a comparison of the meteorological elements in each of the output regional screening meteorology data sets.

**Figure 1.1 Alberta Environment Administrative Regions**

## 2.0 REGIONAL METEOROLOGY INPUT DATA SITES

In a similar project initiated by AENV in 1999, six regionally representative screening meteorology data sets appropriate for the U.S. EPA ISCST3 and CALPUFF (screening mode only) dispersion models, were prepared, and made available to the public on the AENV website ((http://www3.gov.ab.ca/env/air/airqual/airmodelling.html). During that project, considerable effort was spent selecting the representative meteorological monitoring surface data stations (and the five-year monitoring periods), for each of the six AENV administrative regions. During the initial stage of the current project, it was agreed that in the interest of consistency, the same meteorological surface stations (and five-year monitoring periods) would be applied to this project, eliminating a repeat of the selection process. The AERMOD dispersion model meteorological preprocessor AERMET also requires upper air meteorology data. Discussions with AENV staff concluded that the upper air monitoring station located at Stony Plain, Alberta would be applied to four most northern administrative regions. Upper air data from the U.S. Montana Great Falls monitoring station was applied to the two most southerly administrative regions. A summary of the surface and upper air meteorology monitoring stations used in this project for each of the six AENV administrative regions is provided in Table 2.1. The variation in the five-year periods, at each of the six regional surface monitoring stations, is the result of local differences in the data collection procedures. The final five year periods were selected to ensure that there were 24 hours of meteorological observations per day, and that none of the required meteorology parameters were missing for substantial periods of time. It is generally agreed that meteorological monitoring data used for dispersion model inputs should be at least 90% complete (or less than 10% missing data). The final five-year periods, selected for each of the six regions, were based on the most recent surface monitoring station data with at better than 90% data recovery.

**Table 2.1 AENV Administrative Regions, Surface and Upper Air Monitoring Stations, and 5-Year Periods for the AERMOD Input Screening Meteorology Data Sets**

| | | | |
|---|---|---|---|
| Northwest Boreal | Peace River | Stony Plain | 1993 to 1997 |
| Northeast Boreal | Edmonton Namao | Stony Plain | 1990 to 1994 |
| Northern East Slopes | Edson | Stony Plain | 1986 to 1990 |
| Parkland | Red Deer | Stony Plain | 1993 to 1997 |
| Bow | Calgary | Great Falls | 1994 to 1998 |
| Prairie | Medicine Hat | Great Falls | 1993 to 1997 |

## 3.0 CD-144 AND TD6201 INPUT DATA

The AERMET meteorological preprocessor was designed to read input surface and upper air input meteorology data sets using formats available from the meteorological monitoring services in the United States. Typical Canadian surface and upper air meteorology data formats, which can be obtained from the Climate Services Division of Environment Canada, do not specifically correspond to the U.S. formats, currently compatible with the AERMET preprocessor. However, a new specialty data preparation service out of the Environment Canada, Winnipeg, Climate Services Branch, provides users with hourly surface meteorological data in the CD-144 format, and the twice daily upper air meteorology data in the TD6201 format, which can be processed by AERMET. CD-144 surface data, and the TD6201 upper air meteorology data corresponding the surface and upper air monitoring stations, the six AENV administrative regions, and five year monitoring periods indicated in Table 2.1, were purchased from Environment Canada for the purposes of this project. The following sections outline the meteorology parameters included in the CD-144 and TD6201 data sets, and the quality control/quality assurance (QA/QC) procedures that were applied to these data sets.

### 3.1 CD-144 Data

The CD-144 surface data sets are composed of hourly meteorological parameters outlined in Table 3.1. In addition to the temporal elements (year, month, day, and hour), these data sets include surface hourly meteorology data pertaining to ceiling (lowest cloud level), wind speed and direction, ambient temperature, and cloud data (total cloud cover and total cloud opacity). The six regional CD-144 surface data meteorology sets were reviewed as part of the QA/QC process for data completeness, data out of range, and to identify calm wind conditions. In the QA/QC process each meteorological parameter was visually scanned as a set of graphical time series plots to look for missing data, calm wind data, data with no change over time (indicative of the problems with the data collection system), and data out of possible range. The CD-144 data sets received from Environment Canada contained no missing data elements, however wind data representing calm conditions (wind speeds < 1m/s, and a zero wind direction) were found. A data correction program was written to set all calm wind speeds less than 1m/s, to 1 m/s, and to set the associated zero wind directions to a randomly assigned wind direction for that hour. The percentage of the hourly calm wind speed and wind direction values in the CD-144 data sets at each monitoring station, which were replaced are as follows:

Surface Station Percent Hourly Calm Winds

- Calgary – 7.12%
- Edson – 28.33%
- Edmonton Namao - 4.86%
- Medicine Hat - 14.15%
- Peace River - 13.69%
- Red Deer - 12.68%

No other problems with the CD-144 data were identified.

**Table 3.1 CD-144 Surface Data Set Parameters**

| | | | |
|---|---|---|---|
| **Station Number** | - | XXXXX | 1 – 5 |
| **Year** | Year | XX | 6 – 7 |
| **Month** | Month | XX | 8 –9 |
| **Day** | Day | XX | 10 – 11 |
| **Hour** | Hour | XX | 12 –13 |
| **Ceiling Height** | Hundreds of Feet | XXX | 14 – 16 |
| **Wind Direction** | Tens of Degrees From | XX | 39 – 40 |
| **Wind Speed** | Knots | XX | 41 – 42 |
| **Dry Bulb Temperature** | Degrees F | XXX | 47 – 49 |
| **Total Cloud Cover** | Tenths | X | 56 |
| **Total Cloud Opacity** | Tenths | X | 79 |

## 3.2 TD6201 Data

The six regional TD6201 upper air data sets are composed of the twice-daily meteorological parameters summarized in Table 3.2. Along with the location (latitude/longitude), and temporal data (year, month, day, and hour), elements in these files include meteorological data for a maximum of 79 levels in the atmosphere, for pressure, temperature, relative humidity, wind speed, and wind direction. For the purposes of this project the data in the first 20 levels (below 6500m or a pressure of 4,450mb) was the main focus as the AERMET meteorology preprocessor confines the analysis of upper air data to below 5000 m. The reporting levels are not equally spaced in the vertical. In general the first reporting level is at a height of 750 m, and a pressure of 9,233 mb. The spacing between the first few levels is roughly 165 m, while the spacing between levels 15 to 20 averages 375 m. In general the upper air data is archived twice per day reflecting two accents. Serious meteorological conditions such as potential local storm formation, and or the implementation of special monitoring programs can result in more than two upper air accents per day.

The upper air TD6201 data sets received from Environment Canada were reviewed for data completeness, and to identify periods with calm wind conditions. In the QA/QC process each meteorological parameter was visually scanned as a set of graphical time series plots to look for missing data, calm wind data, data with no change over time, and data out of possible range. Although no single accent was found where any particular meteorological parameter was missing

**Table 3.2 D-6201 Upper Air Data Set Parameters**

| | | | |
|---|---|---|---|
| **Station ID** | - | XXXXXXXX | 1 – 8 |
| **Latitude** | Degrees N or S | XX | 9 – 13 |
| **Longitude** | Degrees E or W | XX | 14 –19 |
| **Year** | Year | XXXX | 20 – 23 |
| **Month** | Month | XX | 24 – 25 |
| **Day** | Day | XX | 26 – 27 |
| **Hour** | Hour | XX | 28 – 29 |
| **Time Elapsed Since Accent*** | Minutes and Tenths | | 34 – 37 |
| **Pressure*** | KiloPascals and Hundredths | XXX | 38 – 42 |
| **Height*** | Geopotential Meters | XX | 43 – 48 |
| **Dry Bulb Temperature*** | Degrees F | XXX | 49 – 52 |
| **Relative Humidity*** | Tenths | X | 53 – 55 |
| **Wind Direction*** | Tens of Degrees From | XX | 56 – 58 |
| **Wind Speed*** | Knots | XX | 59 – 61 |

* These parameters are repeated for up to 79 levels in the atmosphere.

at all levels, wind speed and direction values were found to be missing for up to half of the lower 20 reporting levels (which typically extend up to 5000 m). The corresponding upper air pressure, temperature, and relative humidity data was found to be missing roughly 1% of the time. The rather high frequency of missing upper air wind speed and wind direction data was reported to Environment Canada, and confirmed by their technicians. A problem in the Environment Canada upper air data UAS format archives (used to prepare the TD6201 data sets) was identified, where wind direction and wind speed data was assigned as missing, at an inordinately high frequency. A similar upper air data base in the Environment Canada archives designated as the UAW format, did not exhibit the high frequency of missing wind data, however the reported levels were not exactly the same as in the UAS format. Environment Canada personnel in the Edmonton Climate Archives group provided URS with UAS formatted upper air data for the time periods in question. The AERMET meteorology preprocessor utilizes upper air data in the lower levels of the atmosphere up to 5000m, hence only data in these levels were a concern for this project. A correction program was written to read the TD6201 data

(which was based on the UAS formatted files), and correct the missing wind data by interpolating the data in the UAW formatted files to the upper air levels reported in the TD6201 data. In addition, data reflecting calm wind conditions, were replaced with wind speeds of 1m/s, and a randomly assigned wind direction. The first and second reporting levels have the highest frequency of calm conditions (frequencies ranging from 0.3 to 6.7 % in the upper air data sets used for this study). Calm conditions in the reporting levels 3 through 20, ranged from 0.0 to 1.25 %, for any specific level.

# 4.0 SITE SURFACE CHARACTERISTICS

In addition to requiring meteorological surface and upper air data, the AERMET preprocessor requires specific site surface characteristic data. The site surface characteristic parameters required by AERMET include surface roughness, surface albedo, and mid day bowen ratio. These site surface characteristics can be assigned by wind direction sector, and by month of the year. Since the objective of this project is to prepare regional screening meteorology data sets (as opposed to preparing a site specific data set), the variation in these surface characteristic parameters were related to only the month of year, but not related to the wind direction sectors.

Definitions of the required site surface characteristic parameters are as follows:

- Albedo – The fraction of total incident solar radiation reflected by a particular surface without absorption. Typical values range from 0.9 for fresh snow surfaces to 0.1 for a thick deciduous forest.

- Bowen Ratio – An indicator of surface moisture conditions, defined as the ratio of the sensible heat flux to the latent heat flux. While this parameter can vary significantly over the course of one day, it usually attains a fairly constant value during mid day.

- Surface Roughness – A length scale that characterizes the roughness of a surface. The roughness length is the height above ground were the horizontal wind speed is zero.

The goal in this task was to provide monthly representative albedo, bowen ratio, and surface roughness data values for each of the six AENV administrative regions based on published literature or recent monitoring programs. A literature search was conducted in local library's for references concerning monthly representative Alberta regional mid day albedo's, mid day bowen ratios, and surface roughness values. Although a few references cite single values for a specific vegetation or land use type, the best reference was contained in the AERMET user manual (reference #1). In addition several specialized researchers from universities, governments, private industries, and meteorological monitoring consultants were contacted, to identify any recent data collection programs concerned with the site surface characteristic parameters. Since these type of research monitoring programs entail a great deal of cost and effort, none of the researchers contacted was willing or able to provide the type of data requested.

The AERMET user manual contains a variety of tabular values for surface roughness, bowen ratios, and albedo's for eight different land use/vegetation types. These values are presented by season (4 values per year). The tabular values in the AERMET user's manual are referenced to the U.S. EPA CTDM dispersion model METPRO meteorological pre-processor user manual (reference #2). The seasonal albedo, bowen ratio, and surface roughness values cited in the AERMET user manual are organized by the following land use categories:

- Water
- Deciduous Forest
- Coniferous Forest

- Swamp
- Cultivated land
- Grassland
- Urban
- Desert Shrubland

The 1992 Maps Alberta, Resource Information Branch, Land Information Services, Ecoregions of Alberta Provincial Base Map (reference #3) was used to assign representative land use categories to each of the six administrative regions. The resulting dominant land use classifications for each of the six Alberta Environment administrative regions are summarized in Table 4.1. The Northwest Boreal region was designated as deciduous forest. For the Northeast Boreal and the North East Slopes regions a mix land use category of Deciduous/Conifer Forest was assigned. The Parkland region was deemed to be a deciduous/grassland mix land use. Both southern regions (Bow and Prairie) were assigned a grassland land use category.

Based on the tabular values in the AERMET users manual monthly surface roughness, albedo's, and daytime bowen ratios were calculated by averaging the values in the case of a land use mix, and interpolating the seasonal values to monthly ones. Additional albedo data collected over a grass surface in a central Alberta monitoring study were applied to the grassland land use category (reference #4).

The final monthly albedo, daytime bowen ratio, and surface roughness values for each of the six Alberta Environment administrative regions are summarized in tables 4.2 to 4.7. The values in tables 4.2 to 4.7 can be summarized as follows:

- Albedo values in the Bow and Prairie regions are the largest.
- The Parkland and Northeast Boreal albedo values are in the midrange of the overall values.
- The smallest albedo values are found in the Northeast Slopes and Northwest Boreal regions.
- Albedo values during the months of April to October are the smallest, with values from November to March yielding the larger values. The largest albedo values occur in January and December.

The same albedo, bowen ratio, and surface roughness information outlined in tables 4.2 to 4.7 is summarized graphically in figures 4.1 to 4.3.

**Table 4.1 AENV Administrative Regions, and the Dominant land Use Categories Based on information Presented in the 1992 Ecoregions of Alberta Provincial Base Map**

| | |
|---|---|
| Northwest Boreal | Deciduous Forest |
| Northeast Boreal | Deciduous/Conifer Forest Mix |
| Northern East Slopes | Deciduous/Conifer Forest Mix |
| Parkland | Deciduous/Grassland Mix |
| Bow | Grassland |
| Prairie | Grassland |

- Bowen Ratio values in the six respective administrative regions are reasonably similar for any month, with the largest departures found in the months of April and July.
- Bowen Ratios in the months of April to August are the smallest, with values from September to March yielding the larger values. The largest bowen ratio values occur in January and December.
- Surface roughness values in the Bow and Prairie regions are the smallest.
- The Parkland and Northeast Boreal surface roughness values are in the midrange of the overall values.
- The largest surface roughness values are found in the Northeast Slopes and Northwest Boreal regions.
- Surface roughness values during the months of April to September are the largest, with values from October to March yielding the smaller values. The largest surface roughness values occur in July.

**Table 4.2 Monthly Albedo, Surface Roughness and Daytime Bowen Ratio Values for the AENV *Northeast Boreal* Administrative Region**

| | | | |
|---|---|---|---|
| Jan | 0.500 | 0.50 | 1.50 |
| Feb | 0.667 | 0.37 | 1.23 |
| Mar | 0.833 | 0.25 | 0.97 |
| Apr | 1.000 | 0.12 | 0.70 |
| May | 1.100 | 0.12 | 0.57 |
| June | 1.200 | 0.12 | 0.43 |
| July | 1.300 | 0.12 | 0.30 |
| Aug | 1.133 | 0.12 | 0.53 |
| Sept | 0.967 | 0.12 | 0.77 |
| Oct | 0.800 | 0.12 | 1.00 |
| Nov | 0.700 | 0.25 | 1.17 |
| Dec | 0.600 | 0.37 | 1.33 |

**Table 4.3 Monthly Albedo, Surface Roughness and Daytime Bowen Ratio Values for the AENV Northwest Boreal Administrative Region**

| | | | |
|---|---|---|---|
| Jan | 0.900 | 0.425 | 1.500 |
| Feb | 0.983 | 0.323 | 1.233 |
| Mar | 1.067 | 0.222 | 0.967 |
| Apr | 1.150 | 0.120 | 0.700 |
| May | 1.200 | 0.120 | 0.567 |
| June | 1.250 | 0.120 | 0.433 |
| July | 1.300 | 0.120 | 0.300 |
| Aug | 1.217 | 0.120 | 0.500 |
| Sept | 1.133 | 0.120 | 0.700 |
| Oct | 1.050 | 0.120 | 0.900 |
| Nov | 1.000 | 0.222 | 1.100 |
| Dec | 0.950 | 0.323 | 1.300 |

**Table 4.4** **Monthly Albedo, Surface Roughness and Daytime Bowen Ratio Values for the AENV *Northeast Slopes* Administrative Region**

| | | | |
|---|---|---|---|
| Jan | 0.900 | 0.425 | 1.500 |
| Feb | 0.983 | 0.323 | 1.233 |
| Mar | 1.067 | 0.222 | 0.967 |
| Apr | 1.150 | 0.120 | 0.700 |
| May | 1.200 | 0.120 | 0.567 |
| June | 1.250 | 0.120 | 0.433 |
| July | 1.300 | 0.120 | 0.300 |
| Aug | 1.217 | 0.120 | 0.500 |
| Sept | 1.133 | 0.120 | 0.700 |
| Oct | 1.050 | 0.120 | 0.900 |
| Nov | 1.000 | 0.222 | 1.100 |
| Dec | 0.950 | 0.323 | 1.300 |

**Table 4.5** **Monthly Albedo, Surface Roughness and Daytime Bowen Ratio Values for the AENV *Parkland* Administrative Region**

| | | | |
|---|---|---|---|
| Jan | 0.253 | 0.580 | 1.500 |
| Feb | 0.342 | 0.448 | 1.175 |
| Mar | 0.431 | 0.317 | 0.850 |
| Apr | 0.520 | 0.185 | 0.525 |
| May | 0.588 | 0.168 | 0.508 |
| June | 0.657 | 0.152 | 0.492 |
| July | 0.725 | 0.135 | 0.475 |
| Aug | 0.622 | 0.145 | 0.625 |
| Sept | 0.518 | 0.155 | 0.775 |
| Oct | 0.415 | 0.165 | 0.925 |
| Nov | 0.361 | 0.303 | 1.117 |
| Dec | 0.307 | 0.442 | 1.308 |

**Table 4.6 Monthly Albedo, Surface Roughness and Daytime Bowen Ratio Values for the AENV *Bow* Administrative Region**

| | | | |
|---|---|---|---|
| Jan | 0.005 | 0.66 | 1.50 |
| Feb | 0.017 | 0.52 | 1.12 |
| Mar | 0.028 | 0.39 | 0.73 |
| Apr | 0.040 | 0.25 | 0.35 |
| May | 0.077 | 0.22 | 0.45 |
| June | 0.113 | 0.18 | 0.55 |
| July | 0.150 | 0.15 | 0.65 |
| Aug | 0.110 | 0.17 | 0.72 |
| Sept | 0.070 | 0.19 | 0.78 |
| Oct | 0.030 | 0.21 | 0.85 |
| Nov | 0.022 | 0.36 | 1.07 |
| Dec | 0.013 | 0.51 | 1.28 |

**Table 4.7 Monthly Albedo, Surface Roughness and Daytime Bowen Ratio Values for the AENV *Prairie* Administrative Region**

| | | | |
|---|---|---|---|
| Jan | 0.005 | 0.66 | 1.50 |
| Feb | 0.017 | 0.52 | 1.12 |
| Mar | 0.028 | 0.39 | 0.73 |
| Apr | 0.040 | 0.25 | 0.35 |
| May | 0.077 | 0.22 | 0.45 |
| June | 0.113 | 0.18 | 0.55 |
| July | 0.150 | 0.15 | 0.65 |
| Aug | 0.110 | 0.17 | 0.72 |
| Sept | 0.070 | 0.19 | 0.78 |
| Oct | 0.030 | 0.21 | 0.85 |
| Nov | 0.022 | 0.36 | 1.07 |
| Dec | 0.013 | 0.51 | 1.28 |

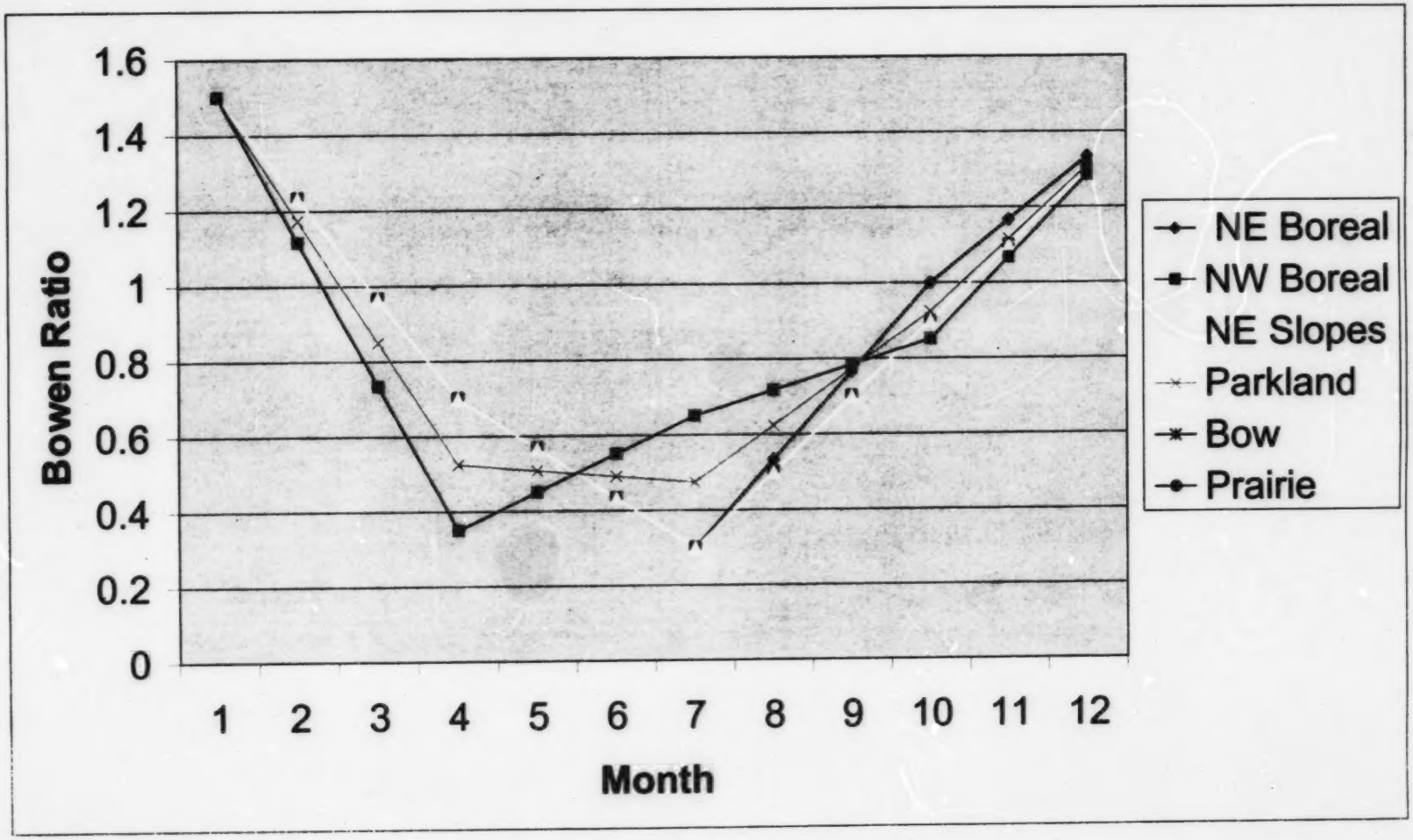


**Figure 4.1 Monthly Variation of the Six Regional Bowen Ratio Values**

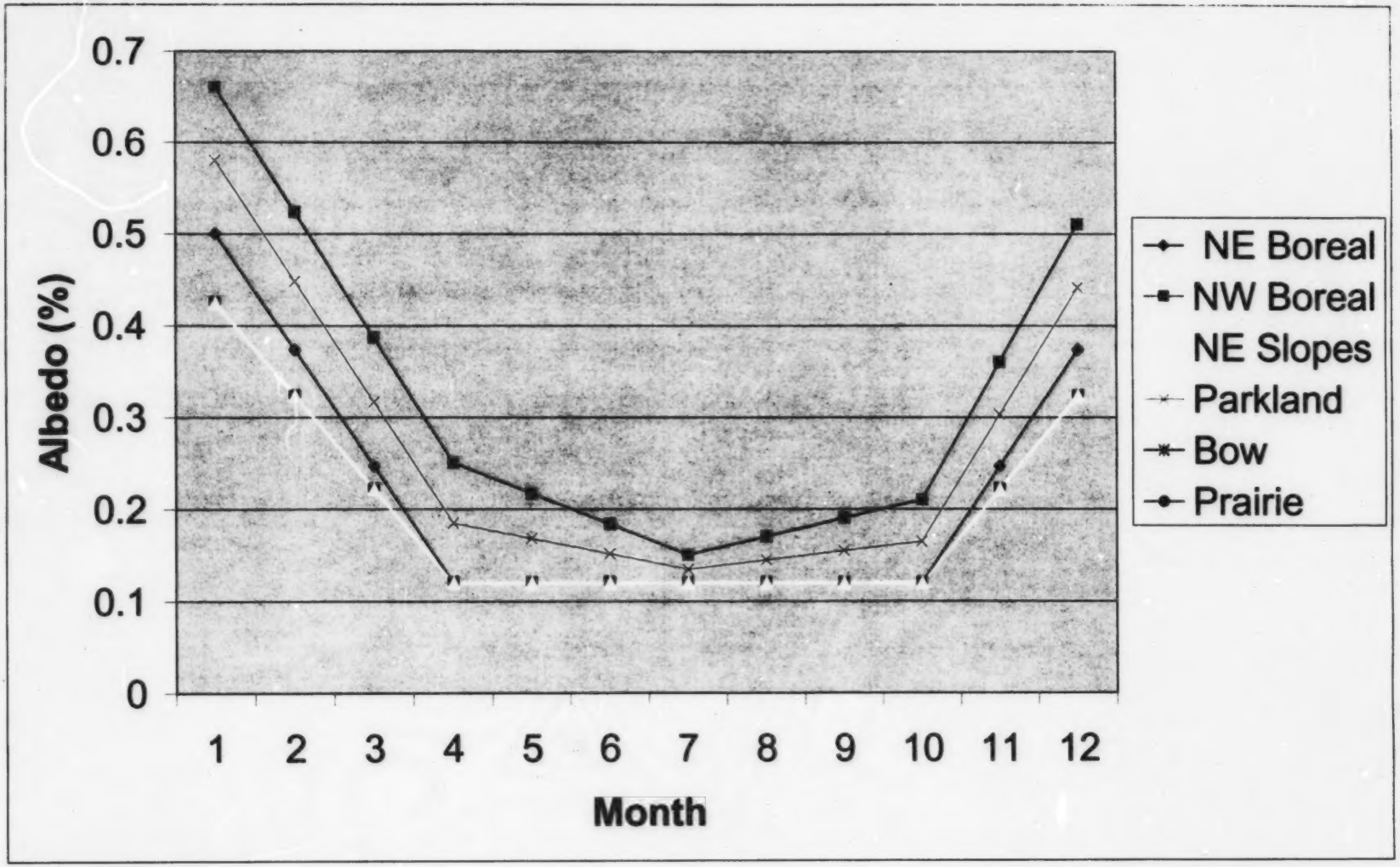


**Figure 4.2 Monthly Variation of the Six Regional Albedo Ratio Values**

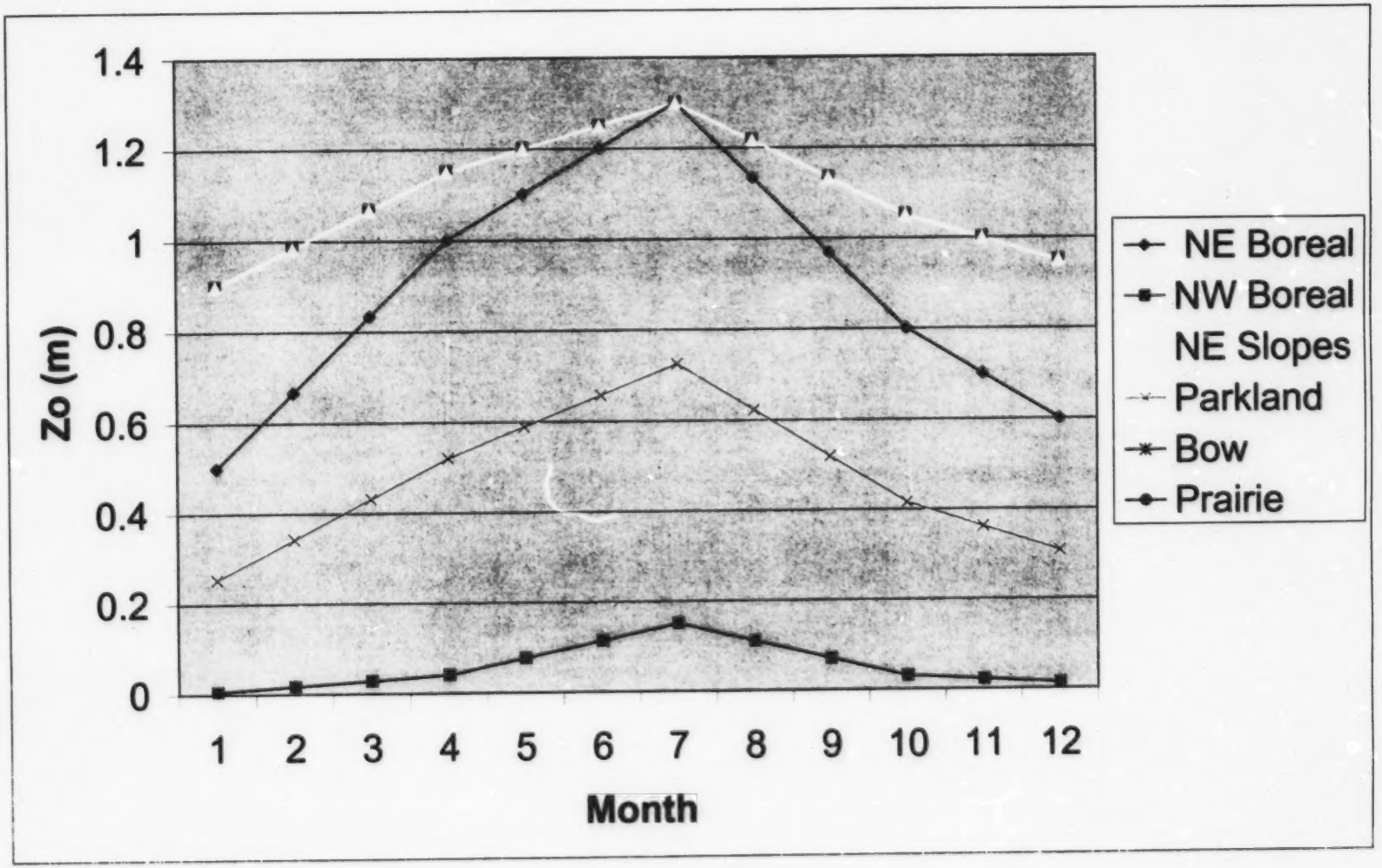


**Figure 4.3 Monthly Variation of the Six Regional Surface Roughness Values**

# 5.0 AERMET OUTPUT FILES

The AERMET preprocessor outputs two meteorological input files for the AERMOD dispersion model. These files are referred to as the 'Surface' and 'Profile' input meteorology files, and are in a time series format with values for each hour of a specified period. The parameters contained in the 'Surface' AERMET output files are outlined in Table 5.1. In addition to the station location, the station identifier, the AERMET version, and the temporal data (year, month, day, julian day, and hour), the 'Surface' data sets include the following:

- sensible heat flux,
- surface friction velocity,
- convective velocity scale,
- vertical potential temperature gradient above the planetary boundary layer,
- convective mixing height,
- mechanical mixing height,
- monin-obukhov length,
- surface roughness length,
- bowen ratio,
- albedo,
- wind speed,
- wind direction,
- temperature,
- and the meteorological monitoring data reference heights.

A comparison of the regional values for each parameter follows in section 5.1.

Table 5.2 outlines the parameters contained in the 'Profile' AERMET output file. The parameters included in the ''Profile' file include temporal values (year, month, day, and hour), measurement height for the on-site data, the number of reported levels, wind direction, wind speed, temperature, standard deviation of the horizontal wind direction, and the standard deviation of the vertical wind speed. Since no on-site specific meteorological data was used in preparing the six regional AERMOD input meteorology data sets (as these data sets are regional screening in nature as opposed to site specific), there are no wind standard deviation values. And as such, the parameters (wind direction, wind speed, and ambient temperature) in the 'Profile' data sets are exactly the same as those in the surface data sets. (except that the temperature is in degrees C, as opposed to degrees K).

## 5.1 Comparison of the Aermet Output Regional Screening Meteorology Data Sets

This section compares the frequency distributions of the meteorological elements contained in the AERMET output surface and profile data files (see tables 5.1 and 5.2) for each of the six AENV regions.

**Table 5.1 AERMET Output 'Surface' Meteorological Data Set Parameters**

| Parameter | Units | Format | File Location (Columns) |
|---|---|---|---|
| Site Latitude | Degrees N or S | XXXXXXXX | 1-10 (First Record) |
| Site Longitude | Degrees E or W | XXXXXXXX | 11-20 (First Record) |
| Upper Air Station Identifier | - | XXXXXXXX | 31-45 (First Record) |
| Surface Station Identifier | - | XXXXXXXX | 48-62 (First Record) |
| On-Site Station Identifier | - | XXXXXXXX | 65-79 (First Record) |
| AERMET Preprocessor Version Number | - | XXXXXX | 85-98 (First Record) |
| Year | Year | XX | 1-2 (All Subsequent Records) |
| Month | Month | XX | 4-5 |
| Day | Day | XX | 7-8 |
| Julian Day | Julian Day | XXX | 10-12 |
| Hour | Hour | XX | 14-15 |
| Sensible Heat Flux | $W/m^2$ | XXXXX.X | 17-22 |
| Surface Friction Velocity | m/s | XXX.XXX | 24-29 |
| Convective Velocity Scale | m/s | XXX.XXX | 31-36 |
| Vertical Potential Temperature Gradient above PBL | Degrees/m | XXX.XXX | 38-43 |
| Height of Convectively-Generated Boundary Layer | m | XXXXX | 45-49 |
| Height of Mechanically-Generated Boundary Layer | m | XXXXX | 51-55 |
| Monin-Obukhov Length | m | XXXXXXX.X | 57-64 |
| Surface Roughness Length | m | XXX.XXX | 66-71 |
| Bowen Ratio | Dimensionless | XXXX.XX | 73-78 |
| Albedo | % Reflection | XXXX.XX | 80-85 |
| Wind Speed | m/s | XXXXX.XX | 87-93 |
| Wind Direction | Degrees From | XXXXX | 95-99 |
| Reference Height for Winds | m | XXXXX.X | 101-106 |
| Ambient Temperature | Degrees K | XXXXX.X | 108-113 |
| Reference Height for Temperature | m | XXXXX.X | 115-120 |

**Table 5.2 AERMET Output 'Profile' Meteorological Data Set Parameters**

| Parameter | Units | Format | File Location (Columns) |
|---|---|---|---|
| **Year** | Year | XX | 1-2 |
| **Month** | Month | XX | 4-5 |
| **Day** | Day | XX | 7-8 |
| **Hour** | Hour | XX | 10-11 |
| **Measurement Height** | m | XXXXX.X | 13-18 |
| **Last Level Identifier** | m | X | 20 |
| **Wind Direction** | Degrees from | XXXXX | 22-26 |
| **Wind Speed** | m/s | XXXXX.XX | 28-34 |
| **Ambient Temperature** | Degrees C | XXXXXX.X | 36-42 |
| **Standard Deviation of Horizontal Wind Direction** | Degrees | XXXXX.X | 44-49 |
| **Standard Deviation of Vertical Wind Speed** | m/s | XXXXX.XX | 51-57 |

### *5.1.1 Sensible Heat Flux – H ($W/m^2$)*

The sensible heat flux values contained in the AERMET output six regional screening meteorology data sets were analyzed to generate the respective regional frequency distributions. Table 5.3 and Figure 5.1 show the tabular frequency distributions, and the equivalent graphical frequencies in the form of a joint histogram. The most frequent sensible heat flux range is –20 to 0 $W/m^2$ for all six regional data sets (frequency's ranging from 23.47% at Edmonton Namao to 45.69% at Edson). This result is similar to the observations cited in the ERCB field measurement program (reference #5), where sonic anemometer data collected in a field northeast of Calgary was used to calculate the sensible heat flux values. Median values of the sensible heat flux based on 10m observations, in the ERCB study, ranged from –1 to –15 $W/m^2$. The least frequent range of sensible heat flux values are those in excess of 200 $W/m^2$ with the Edmonton Namao, Edson, Peace River and Red Deer having no values, and Calgary and Medicine Hat both less than 0.2%.

### *5.1.2 Surface Friction Velocity – U* (m/s)*

The surface friction velocity values contained in the AERMET output six regional screening meteorology data sets were analyzed to generate the respective regional frequency distributions. Table 5.4 and Figure 5.2 show the tabular frequency distributions and the equivalent graphical frequencies in the form of a joint histogram. The most frequent surface friction velocity range is

**Table 5.3 Sensible Heat Flux Distribution Summary For Each AENV AERMET Regional Meteorology Data Set**

| Sensible Heat Flux Range ($W/m^2$) | Station Name | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Calgary | | Edmonton Namao | | Edson | | Medicine Hat | | Peace River | | Red Deer | |
| | Number | (%) | Number | (%) | Number | (%) | Number | (%) | Number | (%) | Number | (%) |
| -80 to –60 | 659 | 1.504 | 6553 | 14.953 | 2085 | 4.758 | 518 | 1.182 | 7708 | 17.589 | 2069 | 4.721 |
| -60 to -40 | 1875 | 4.278 | 4914 | 11.213 | 1853 | 4.228 | 2109 | 4.812 | 3926 | 8.959 | 4067 | 9.280 |
| -40 to –20 | 6447 | 14.711 | 5675 | 12.950 | 3113 | 7.103 | 6409 | 14.624 | 4258 | 9.716 | 5176 | 11.811 |
| -20 to 0 | 18886 | 43.095 | 10284 | 23.467 | 20024 | 45.692 | 18669 | 42.600 | 12132 | 27.683 | 16259 | 37.101 |
| 0 to 20 | 3514 | 8.018 | 3428 | 7.822 | 3834 | 8.749 | 3495 | 7.975 | 3459 | 7.893 | 3536 | 8.069 |
| 20 to 40 | 2785 | 6.355 | 2936 | 6.700 | 2988 | 6.818 | 2899 | 6.615 | 2921 | 6.665 | 3107 | 7.090 |
| 40 to 60 | 1943 | 4.434 | 1789 | 4.082 | 2019 | 4.607 | 1859 | 4.242 | 2010 | 4.587 | 1826 | 4.167 |
| 60 to 80 | 1817 | 4.146 | 1923 | 4.388 | 1937 | 4.420 | 1845 | 4.210 | 1818 | 4.148 | 1835 | 4.187 |
| 80 to 100 | 1561 | 3.562 | 1655 | 3.776 | 1767 | 4.032 | 1521 | 3.471 | 1692 | 3.861 | 1555 | 3.548 |
| 100 to 120 | 1078 | 2.460 | 1802 | 4.112 | 1703 | 3.886 | 1159 | 2.645 | 1627 | 3.713 | 1491 | 3.402 |
| 120 to 140 | 1126 | 2.569 | 1232 | 2.811 | 1248 | 2.848 | 1114 | 2.542 | 1194 | 2.725 | 1251 | 2.855 |
| 140 to 160 | 819 | 1.869 | 1085 | 2.476 | 922 | 2.104 | 882 | 2.013 | 855 | 1.951 | 1145 | 2.613 |
| 160 to 180 | 806 | 1.839 | 521 | 1.189 | 301 | 0.687 | 765 | 1.746 | 224 | 0.511 | 480 | 1.095 |
| 180 to 200 | 484 | 1.104 | 27 | 0.062 | 30 | 0.068 | 505 | 1.152 | 0 | 0.000 | 27 | 0.062 |
| >200 | 24 | 0.055 | 0 | 0.000 | 0 | 0.000 | 75 | 0.171 | 0 | 0.000 | 0 | 0.000 |
| TOTAL | 43 824 | 100 | 43 824 | 100 | 43 824 | 100 | 43 824 | 100 | 43 824 | 100 | 43 824 | 100 |

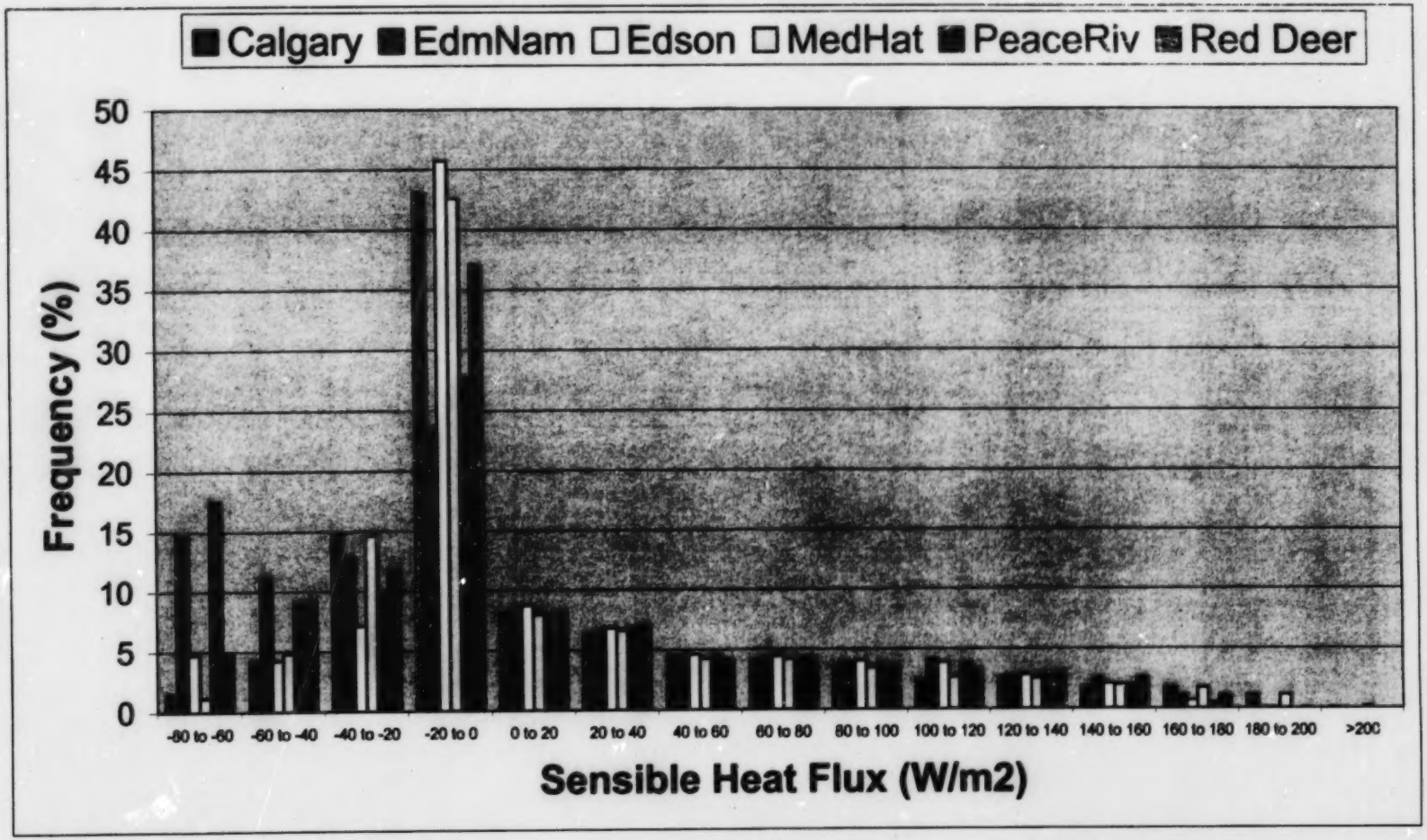


**Figure 5.1** **Joint Histogram of the Sensible Heat Flux values in the six regional AERMET Meteorology Data Sets**

**Table 5.4 Surface Friction Velocity Distribution Summary For Each AENV AERMET Regional Meteorology Data Set**

| Surface Friction Velocity Range (m/s) | Station Name | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Calgary | | Edmonton Namao | | Edson | | Medicine Hat | | Peace River | | Red Deer | |
| | Number | (%) | Number | (%) | Number | (%) | Number | (%) | Number | (%) | Number | (%) |
| 0.0 to 0.2 | 21464 | 48.978 | 9791 | 22.342 | 19837 | 45.265 | 22035 | 50.281 | 11673 | 26.636 | 16629 | 37.945 |
| 0.2 to 0.4 | 12767 | 29.132 | 9652 | 22.024 | 11819 | 26.969 | 11876 | 27.099 | 8507 | 19.412 | 9717 | 22.173 |
| 0.4 to 0.6 | 6445 | 14.707 | 7607 | 17.358 | 4187 | 9.554 | 7140 | 16.292 | 4704 | 10.734 | 7361 | 16.797 |
| 0.6 to 0.8 | 2364 | 5.394 | 7505 | 17.125 | 2783 | 6.350 | 2270 | 5.180 | 5308 | 12.112 | 6260 | 14.284 |
| 0.8 to 1.0 | 606 | 1.383 | 4679 | 10.677 | 2751 | 6.277 | 398 | 0.908 | 6305 | 14.387 | 2416 | 5.513 |
| 1.0 to 1.2 | 150 | 0.342 | 1907 | 4.351 | 988 | 2.254 | 97 | 0.221 | 2835 | 6.469 | 1161 | 2.649 |
| 1.2 to 1.4 | 21 | 0.048 | 1159 | 2.645 | 664 | 1.515 | 8 | 0.018 | 2160 | 4.929 | 201 | 0.459 |
| 1.4 to 1.6 | 6 | 0.014 | 904 | 2.063 | 530 | 1.209 | 0 | 0.000 | 1696 | 3.870 | 50 | 0.114 |
| 1.6 to 1.8 | 1 | 0.002 | 384 | 0.876 | 154 | 0.351 | 0 | 0.000 | 429 | 0.979 | 20 | 0.046 |
| 1.8 to 2.0 | 0 | 0.000 | 108 | 0.246 | 69 | 0.157 | 0 | 0.000 | 123 | 0.281 | 8 | 0.018 |
| 2.0 to 2.2 | 0 | 0.000 | 74 | 0.169 | 27 | 0.062 | 0 | 0.000 | 54 | 0.123 | 1 | 0.002 |
| 2.2 to 2.4 | 0 | 0.000 | 33 | 0.075 | 13 | 0.030 | 0 | 0.000 | 27 | 0.062 | 0 | 0.000 |
| 2.4 to 2.6 | 0 | 0.000 | 14 | 0.032 | 0 | 0.000 | 0 | 0.000 | 1 | 0.002 | 0 | 0.000 |
| 2.6 to 2.8 | 0 | 0.000 | 5 | 0.011 | 2 | 0.005 | 0 | 0.000 | 1 | 0.002 | 0 | 0.000 |
| 2.8 to 3.0 | 0 | 0.000 | 2 | 0.005 | 0 | 0.000 | 0 | 0.000 | 1 | 0.002 | 0 | 0.000 |
| TOTAL | 43 824 | 100 | 43 824 | 100 | 43 824 | 100 | 43 824 | 100 | 43 824 | 100 | 43 824 | 100 |

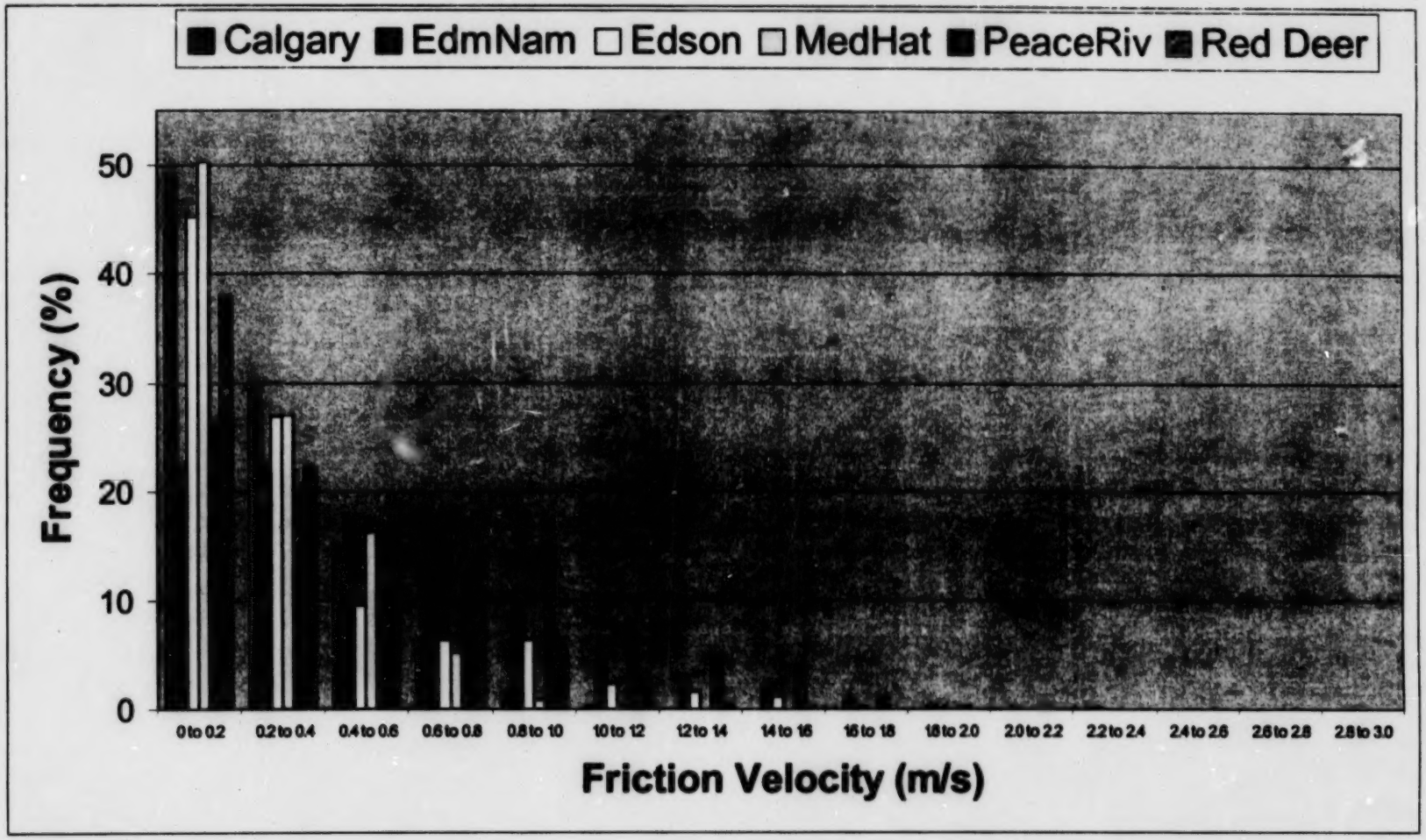


**Figure 5.2 Joint Histogram of the Friction Velocity values in the six regional AERMET Meteorology Data Sets**

0 to 0.2 m/s for all six regional data sets (frequency's ranging from 22.34% at Edmonton Namao to 50.28% at Medicine Hat). The ERCB field measurement study in 1990 (reference #5) also cites the most common friction velocity values for 10m observations, as ranging from 0.10 to 0.19 m/s. The least frequent range of surface friction velocity values are those in excess of 2.8 m/s with the, Edson, Calgary, Medicine Hat and Red Deer having no values, and Peace River and Edmonton Namao only three values between them.

### *5.1.3 Convective Velocity Scale – W* (m/s)*

The convective velocity scale values contained in the AERMET output six regional screening meteorology data sets were analyzed to generate the respective regional frequency distributions. This parameter is only calculated for convective conditions. During non convective conditions the convective velocity scale is assigned as missing. AERMET defines convective conditions as any hour when the sensible heat flux is upward, and the time of day is between sunrise and sunset. The convective velocity scale values are computed by AERMET as a function of the convective mixing height, sensible heat flux, and ambient temperature values (reference #1). Table 5.5 and Figure 5.3 show the tabular frequency distributions, and the equivalent graphical frequencies in the form of a joint histogram. . The most frequent convective velocity scale range is 1.2 to 1.4 m/s for all six regional data sets (frequency's ranging from 9.03% at Edmonton Namao to 12.35% at Peace River). This most common range of the convective velocity scale values reflects a grouping resulting from the mid range of convective mixing height depths, and the mid range of the sensible heat flux values. The least frequent range of convective velocity scale values are those in excess of 2.8 m/s with the, Edson, Peace River, Edmonton Namao and Red Deer having no values, and Calgary, and Medicine Hat only 35 values between them.

### *5.1.4 Vertical Potential Temperature Gradient Above The Planetary Boundary Layer - VPTG (degrees C/m)*

The vertical potential temperature gradient above the planetary boundary layer values contained in the AERMET output six regional screening meteorology data sets were analyzed to generate the respective regional frequency distributions. This parameter is only calculated for convective conditions. During non convective conditions the vertical potential temperature gradient above the planetary boundary layer is assigned as missing. AERMET defines convective conditions as any hour when the sensible heat flux is upward, and the time of day is between sunrise and sunset. The vertical potential temperature gradient above the planetary boundary layer values are computed by AERMET based on the temperature gradient above the convective mixing height found in the input upper air data sets. The AERMOD dispersion model estimates the degree of plume penetration at the convective mixing height level, based on the magnitude of the vertical potential temperature gradient above the planetary boundary layer. Table 5.6 and Figure 5.4 show the tabular frequency distributions, and the equivalent graphical frequencies in the form of a joint histogram. The most frequent vertical potential temperature gradient above the planetary boundary layer range is 0 to 0.02 degrees per meter for all six regional data sets (frequency's ranging from 63.28% at Calgary to 98.99% at Edson). This indicates that the temperature

**Table 5.5 Convective Velocity Scale Distribution Summary For Each AENV AERMET Regional Meteorology Data Set**

| Convective Velocity Scale (m/s) | Station Name | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Calgary | | Edmonton Namao | | Edson | | Medicine Hat | | Peace River | | Red Deer | |
| | Number | (%) | Number | (%) | Number | (%) | Number | (%) | Number | (%) | Number | (%) |
| 0.0 to 0.2 | 574 | 3.616 | 1887 | 11.497 | 1184 | 7.070 | 762 | 4.745 | 1071 | 6.782 | 1169 | 7.197 |
| 0.2 to 0.4 | 936 | 5.897 | 2319 | 14.129 | 1781 | 10.635 | 1147 | 7.142 | 1710 | 10.828 | 1697 | 10.448 |
| 0.4 to 0.6 | 1368 | 8.618 | 2507 | 15.274 | 1897 | 11.328 | 1549 | 9.646 | 1829 | 11.582 | 1935 | 11.914 |
| 0.6 to 0.8 | 1399 | 8.814 | 1917 | 11.680 | 2202 | 13.149 | 1649 | 10.268 | 2077 | 13.152 | 2195 | 13.514 |
| 0.8 to 1.0 | 1449 | 9.129 | 1451 | 8.841 | 1957 | 11.686 | 1681 | 10.468 | 2048 | 12.969 | 1969 | 12.123 |
| 1.0 to 1.2 | 1455 | 9.167 | 1437 | 8.755 | 1929 | 11.519 | 1587 | 9.882 | 2282 | 14.450 | 2128 | 13.102 |
| 1.2 to 1.4 | 1610 | 10.143 | 1482 | 9.029 | 1945 | 11.615 | 1783 | 11.103 | 1950 | 12.348 | 1980 | 12.191 |
| 1.4 to 1.6 | 1540 | 9.702 | 1458 | 8.883 | 1792 | 10.701 | 1624 | 10.113 | 1339 | 8.479 | 1332 | 8.201 |
| 1.6 to 1.8 | 1344 | 8.467 | 1122 | 6.836 | 1202 | 7.178 | 1329 | 8.276 | 868 | 5.496 | 1055 | 6.496 |
| 1.8 to 2.0 | 1246 | 7.850 | 579 | 3.528 | 617 | 3.684 | 1131 | 7.043 | 460 | 2.913 | 598 | 3.682 |
| 2.0 to 2.2 | 1025 | 6.458 | 211 | 1.286 | 204 | 1.218 | 778 | 4.845 | 138 | 0.874 | 168 | 1.034 |
| 2.2 to 2.4 | 704 | 4.435 | 40 | 0.244 | 31 | 0.185 | 431 | 2.684 | 20 | 0.127 | 16 | 0.099 |
| 2.4 to 2.6 | 677 | 4.265 | 3 | 0.018 | 5 | 0.030 | 329 | 2.049 | 0 | 0.000 | 0 | 0.000 |
| 2.6 to 2.8 | 536 | 3.377 | 0 | 0.000 | 0 | 0.000 | 254 | 1.582 | 0 | 0.000 | 0 | 0.000 |
| 2.8 to 3.0 | 10 | 0.063 | 0 | 0.000 | 0 | 0.000 | 25 | 0.156 | 0 | 0.000 | 0 | 0.000 |
| TOTAL | 15889 | 100 | 16400 | 100 | 16727 | 100 | 16191 | 100 | 15809 | 100 | 16256 | 100 |

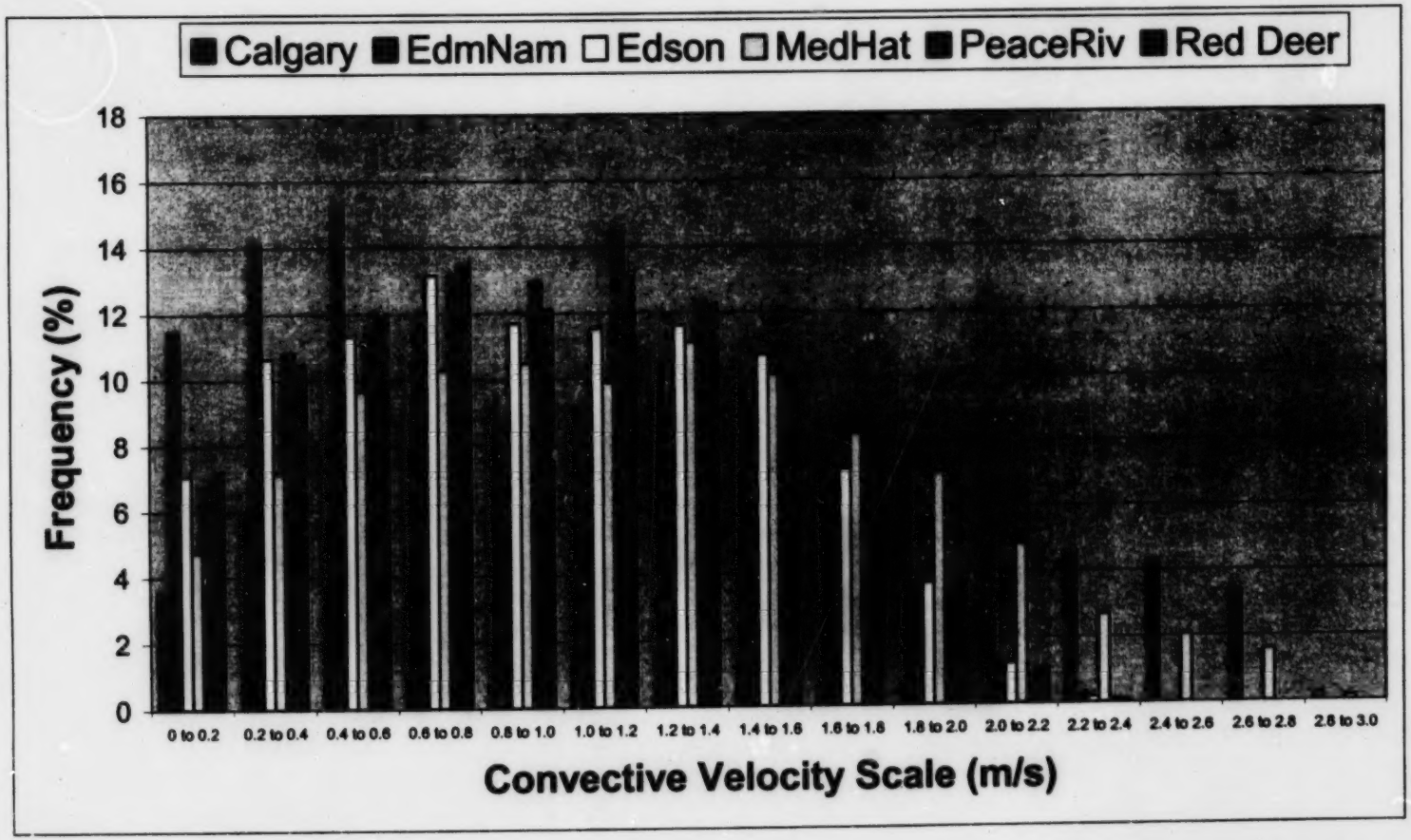


**Figure 5.3 Joint Histogram of the Convective Velocity Scale values in the six regional AERMET Meteorology Data Sets**

**Table 5.6 Vertical Potential Temperature Gradient (VPTG) above the PBL distribution summary for each AENV AERMET Regional Meteorology Data Set**

| VPTG | Station Name | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Calgary | | Edmonton Namao | | Edson | | Medicine Hat | | Peace River | | Red Deer | |
| (degrees C/m) | Number | (%) | Number | (%) | Number | (%) | Number | (%) | Number | (%) | Number | (%) |
| 0.0 to 0.02 | 10045 | 63.284 | 14988 | 91.318 | 16578 | 98.997 | 12687 | 79.002 | 14654 | 92.794 | 14620 | 90.014 |
| 0.02 to 0.04 | 118 | 0.743 | 196 | 1.194 | 142 | 0.848 | 144 | 0.897 | 100 | 0.633 | 170 | 1.047 |
| 0.04 to 0.06 | 17 | 0.107 | 135 | 0.823 | 26 | 0.155 | 20 | 0.125 | 18 | 0.114 | 33 | 0.203 |
| 0.06 to 0.08 | 9 | 0.057 | 152 | 0.926 | 0 | 0.000 | 5 | 0.031 | 16 | 0.101 | 18 | 0.111 |
| 0.08 to 0.10 | 1 | 0.006 | 211 | 1.286 | 0 | 0.000 | 4 | 0.025 | 5 | 0.032 | 20 | 0.123 |
| 0.1 to 0.12 | 8 | 0.050 | 216 | 1.316 | 0 | 0.000 | 5 | 0.031 | 15 | 0.095 | 22 | 0.135 |
| 0.12 to 0.14 | 3 | 0.019 | 264 | 1.608 | 0 | 0.000 | 6 | 0.037 | 27 | 0.171 | 24 | 0.148 |
| 0.14 to 0.16 | 8 | 0.050 | 239 | 1.456 | 0 | 0.000 | 14 | 0.087 | 31 | 0.196 | 36 | 0.222 |
| 0.16 to 0.18 | 302 | 1.903 | 12 | 0.073 | 0 | 0.000 | 307 | 1.912 | 57 | 0.361 | 79 | 0.486 |
| 0.18 to 0.20 | 98 | 0.617 | 0 | 0.000 | 0 | 0.000 | 154 | 0.959 | 119 | 0.754 | 103 | 0.634 |
| 0.20 to 0.22 | 3006 | 18.938 | 0 | 0.000 | 0 | 0.000 | 743 | 4.627 | 267 | 1.691 | 373 | 2.297 |
| 0.22 to 0.24 | 2258 | 14.225 | 0 | 0.000 | 0 | 0.000 | 1970 | 12.267 | 348 | 2.204 | 538 | 3.312 |
| 0.24 to 0.26 | 0 | 0.000 | 0 | 0.000 | 0 | 0.000 | 0 | 0.000 | 128 | 0.811 | 205 | 1.262 |
| 0.26 to 0.28 | 0 | 0.000 | 0 | 0.000 | 0 | 0.000 | 0 | 0.000 | 7 | 0.044 | 1 | 0.006 |
| 0.28 to 0.30 | 0 | 0.000 | 0 | 0.000 | 0 | 0.000 | 0 | 0.000 | 0 | 0.000 | 0 | 0.000 |
| TOTAL | 15889 | 100 | 16400 | 100 | 16727 | 100 | 16191 | 100 | 15809 | 100 | 16256 | 100 |

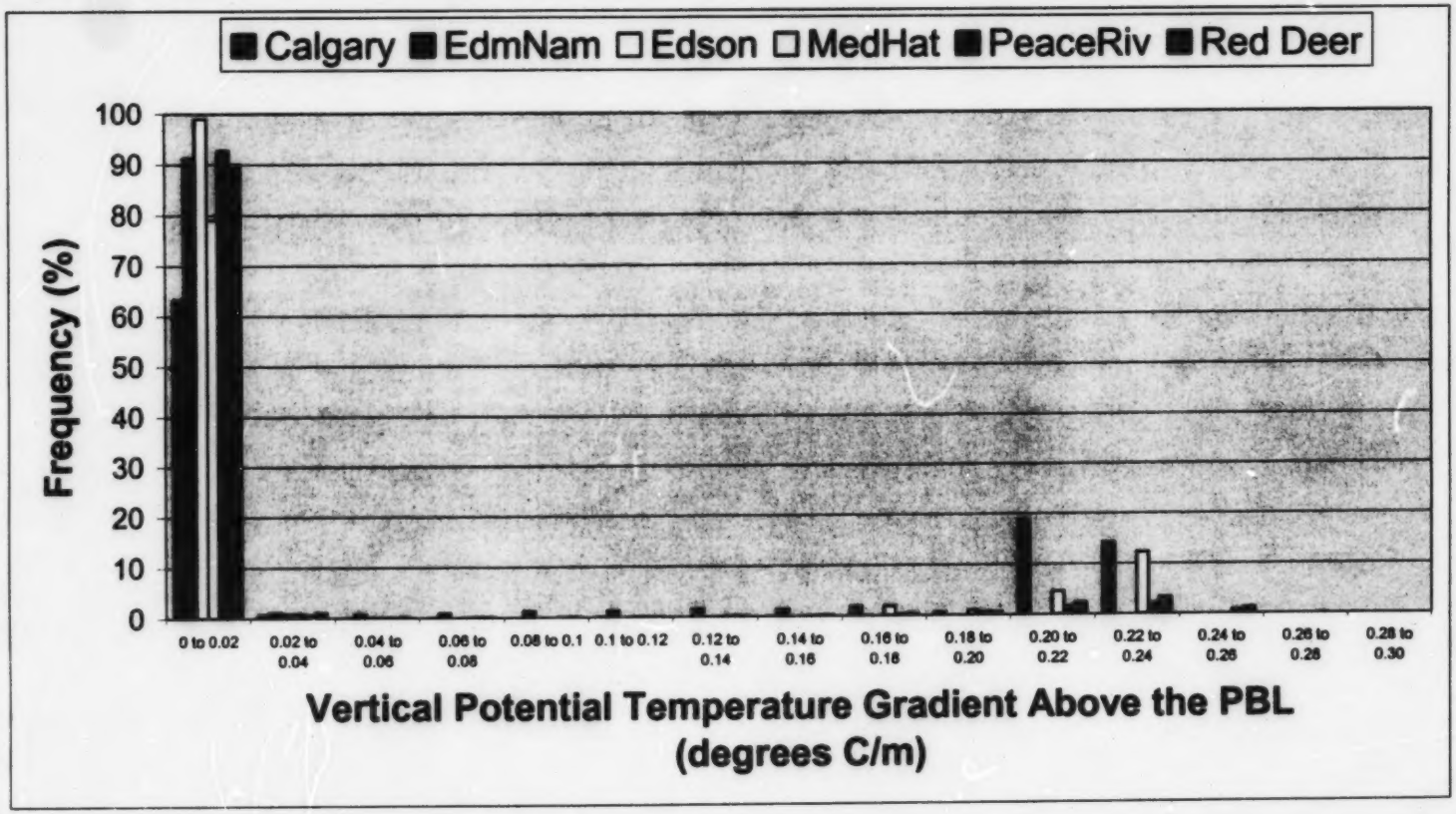


**Figure 5.4 Joint Histogram of the Vertical Potential Temperature Gradient (VPTG) above the Planetary Boundary Layer (PBL) values in the six regional AERMET Meteorology Data Sets**

gradient above the convective mixing height level is usually small in magnitude. The least frequent range of vertical potential temperature gradient above the planetary boundary layer values are those in excess of 0.24 degrees per meter with only Red Deer, and Peace River having non zero frequencies.

### *5.1.5 Convective Mixing Height - Zic (m)*

The convective mixing height values contained in the AERMET output six regional screening meteorology data sets were analyzed to generate the respective regional frequency distributions. This parameter is only calculated for convective conditions. During non convective conditions the convective mixing height is assigned as missing. AERMET defines convective conditions as any hour when the sensible heat flux is upward, and the time of day is between sunrise and sunset. The AERMET convective mixing height values are a function of the sensible heat flux and the potential temperature gradient. AERMET sets the maximum convective mixing height as 4000 m. Table 5.7 and Figure 5.5 show the tabular frequency distributions, and the equivalent graphical frequencies in the form of a joint histogram. The most frequent convective mixing height range is 0 to 250 m for all six regional data sets (frequency's ranging from 16.71% at Calgary to 43.59% at Edmonton Namao). The convective mixing height values are a function of the sensible heat flux in the AERMET preprocessor. The reason for the most frequent convective mixing heights to occur in the 0 to 250 m range is that relatively low solar elevation angles, result in a higher frequency of the small upward sensible heat flux values, for Alberta sites. The smaller upward sensible heat flux values yield smaller convective mixing height values. Many of the small convective mixing height values occur in the months from November to February, when solar elevation angles are small, which yield low upward sensible heat flux values. At Calgary and Medicine Hat convective mixing heights in access of 3750 m are associated with midday summer time hours, with moderate u* and w* values, and large VPTG values. The least frequent range of convective mixing height values are those from 3500 to 3750 m with Edson, Peace River, and Red Deer having no values, and Calgary, Edmonton Namao, and Medicine Hat only 13 values between them.

### *5.1.6 Mechanical Mixing Height – Zim (m)*

The mechanical mixing height values contained in the AERMET output six regional screening meteorology data sets were analyzed to generate the respective regional frequency distributions. The mechanical mixing height values in AERMET are a function of the surface wind speeds. AERMET sets the maximum mechanical mixing height as 4000 m. Table 5.8 and Figure 5.6 show the tabular frequency distributions, and the equivalent graphical frequencies in the form of a joint histogram. The most frequent mechanical mixing height range is 0 to 250 m for all six regional data sets (frequency's ranging from 21.89% at Edmonton Namao to 52.05% at Medicine Hat). The mechanical mixing height values are a function of the wind speed in the AERMET preprocessor. The reason for the most frequent mechanical mixing heights to occur in the 0 to 250 m range are relatively low surface wind speeds in Alberta, especially the central, and northern regions. The least frequent range of mechanical mixing height values are those from 3000 to 3250 m with all stations having less than a 1% frequency.

**Table 5.7 Convective Mixing Height Distribution Summary For Each AENV AERMET Regional Meteorology Data Set**

| Convective Mixing Height (m) | Station Name | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Calgary | | Edmonton Namao | | Edson | | Medicine Hat | | Peace River | | Red Deer | |
| | Number | (%) | Number | (%) | Number | (%) | Number | (%) | Number | (%) | Number | (%) |
| 0 to 250 | 2654 | 16.709 | 7154 | 43.587 | 4956 | 29.595 | 3191 | 19.870 | 4634 | 29.344 | 4780 | 29.430 |
| 250 to 500 | 1262 | 7.945 | 1845 | 11.241 | 2695 | 16.093 | 1652 | 10.287 | 3247 | 20.561 | 3323 | 20.459 |
| 500 to 750 | 1307 | 8.228 | 1471 | 8.962 | 1908 | 11.394 | 1711 | 10.654 | 2400 | 15.198 | 2591 | 15.952 |
| 750 to 1000 | 985 | 6.201 | 1495 | 9.109 | 1787 | 10.671 | 1479 | 9.210 | 1604 | 10.157 | 1511 | 9.303 |
| 1000 to 1250 | 839 | 5.282 | 1142 | 6.958 | 1530 | 9.137 | 1139 | 7.093 | 1119 | 7.086 | 1074 | 6.612 |
| 1250 to 1500 | 1061 | 6.680 | 1074 | 6.544 | 1311 | 7.829 | 1489 | 9.272 | 944 | 5.978 | 888 | 5.467 |
| 1500 to 1750 | 643 | 4.048 | 838 | 5.106 | 961 | 5.739 | 795 | 4.950 | 736 | 4.661 | 832 | 5.123 |
| 1750 to 2000 | 458 | 2.883 | 583 | 3.552 | 704 | 4.204 | 775 | 4.826 | 437 | 2.767 | 516 | 3.177 |
| 2000 to 2250 | 229 | 1.442 | 376 | 2.291 | 353 | 2.108 | 323 | 2.011 | 358 | 2.267 | 366 | 2.253 |
| 2250 to 2500 | 98 | 0.617 | 256 | 1.560 | 307 | 1.833 | 165 | 1.027 | 207 | 1.311 | 251 | 1.545 |
| 2500 to 2750 | 176 | 1.108 | 107 | 0.652 | 152 | 0.908 | 186 | 1.158 | 54 | 0.342 | 62 | 0.382 |
| 2750 to 3000 | 11 | 0.069 | 48 | 0.292 | 54 | 0.322 | 20 | 0.125 | 31 | 0.196 | 26 | 0.160 |
| 3000 to 3250 | 22 | 0.139 | 10 | 0.061 | 17 | 0.102 | 25 | 0.156 | 9 | 0.057 | 11 | 0.068 |
| 3250 to 3500 | 4 | 0.025 | 4 | 0.024 | 11 | 0.066 | 10 | 0.062 | 8 | 0.051 | 6 | 0.037 |
| 3500 to 3750 | 4 | 0.025 | 5 | 0.030 | 0 | 0.000 | 4 | 0.025 | 0 | 0.000 | 0 | 0.000 |
| 3750 to 4000 | 6131 | 38.599 | 5 | 0.030 | 0 | 0.000 | 3095 | 19.273 | 4 | 0.025 | 5 | 0.031 |
| TOTAL | 15901 | 100.0627 | 16400 | 100 | 16727 | 100 | 16191 | 100 | 15809 | 100 | 16256 | 100 |

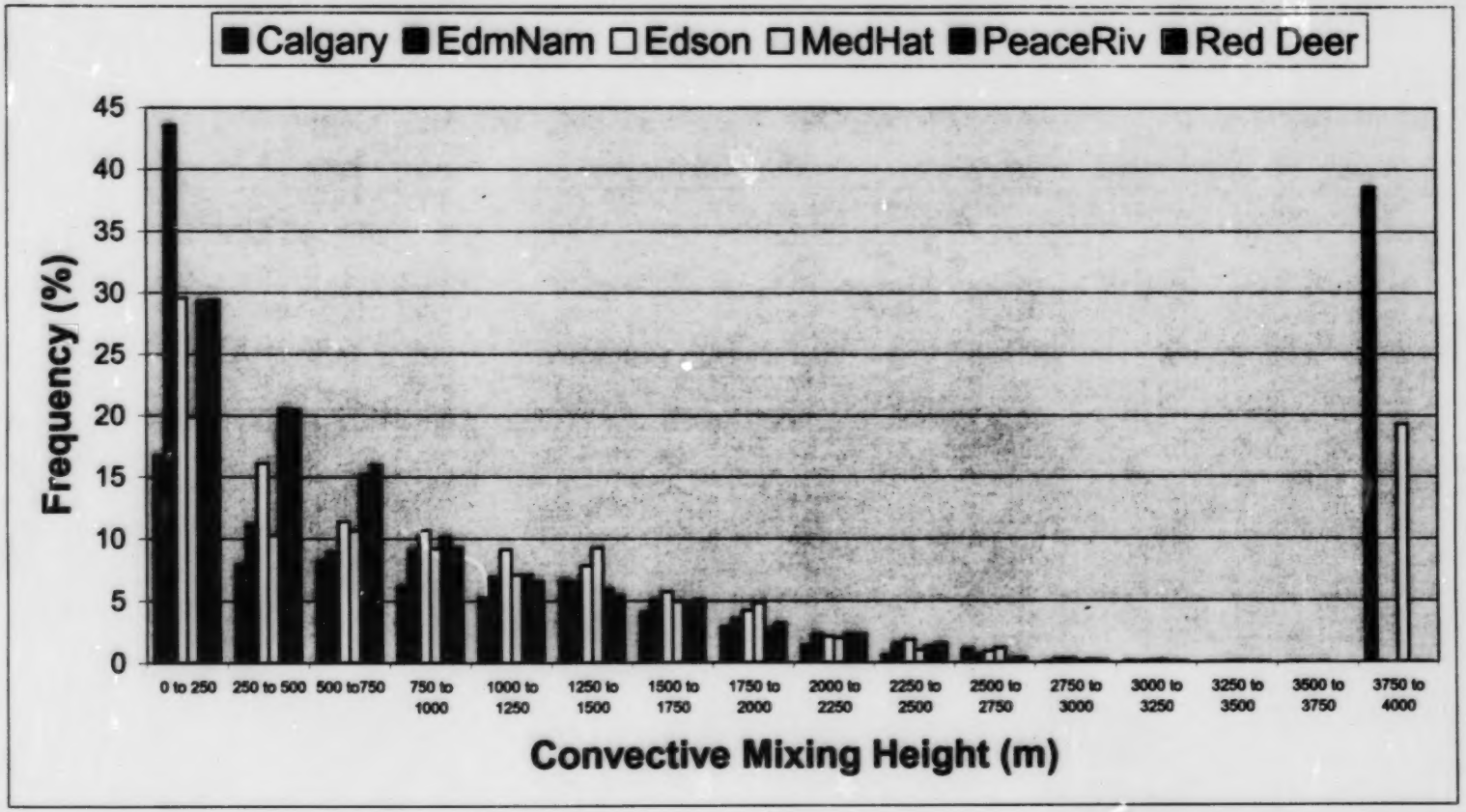


**Figure 5.5 Joint Histogram of the Convective Mixing Height values in the six regional AERMET Meteorology Data Sets**

**Table 5.8 Mechanical Mixing Height Distribution Summary For Each AENV AERMET Regional Meteorology Data Set**

| Mechanical Mixing Height (m) | Station Name | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Calgary | | Edmonton Namao | | Edson | | Medicine Hat | | Peace River | | Red Deer | |
| | Number | (%) | Number | (%) | Number | (%) | Number | (%) | Number | (%) | Number | (%) |
| 0 to 250 | 22598 | 51.565 | 9591 | 21.885 | 19558 | 44.629 | 22808 | 52.045 | 10876 | 24.817 | 16774 | 38.276 |
| 250 to 500 | 9190 | 20.970 | 7302 | 16.662 | 8676 | 19.797 | 8680 | 19.806 | 5943 | 13.561 | 7289 | 16.632 |
| 500 to 750 | 5369 | 12.251 | 4714 | 10.757 | 4097 | 9.349 | 5532 | 12.623 | 4385 | 10.006 | 4482 | 10.227 |
| 750 to 1000 | 2989 | 6.820 | 4021 | 9.175 | 2172 | 4.956 | 3506 | 8.000 | 2059 | 4.698 | 3824 | 8.726 |
| 1000 to 1250 | 1488 | 3.395 | 3617 | 8.253 | 1500 | 3.423 | 1493 | 3.407 | 2422 | 5.527 | 3530 | 8.055 |
| 1250 to 1500 | 1011 | 2.307 | 3541 | 8.080 | 1587 | 3.621 | 1037 | 2.366 | 2804 | 6.398 | 2695 | 6.150 |
| 1500 to 1750 | 563 | 1.285 | 2547 | 5.812 | 1149 | 2.622 | 391 | 0.892 | 2194 | 5.006 | 1850 | 4.221 |
| 1750 to 2000 | 279 | 0.637 | 1847 | 4.215 | 882 | 2.013 | 200 | 0.456 | 2343 | 5.346 | 1115 | 2.544 |
| 2000 to 2250 | 140 | 0.319 | 1619 | 3.694 | 1264 | 2.884 | 66 | 0.151 | 2624 | 5.988 | 705 | 1.609 |
| 2250 to 2500 | 83 | 0.189 | 1035 | 2.362 | 795 | 1.814 | 47 | 0.107 | 1695 | 3.868 | 544 | 1.241 |
| 2500 to 2750 | 51 | 0.116 | 747 | 1.705 | 459 | 1.047 | 42 | 0.096 | 1251 | 2.855 | 472 | 1.077 |
| 2750 to 3000 | 35 | 0.080 | 505 | 1.152 | 176 | 0.402 | 13 | 0.030 | 639 | 1.458 | 247 | 0.564 |
| 3000 to 3250 | 8 | 0.018 | 387 | 0.883 | 176 | 0.402 | 5 | 0.011 | 532 | 1.214 | 115 | 0.262 |
| 3250 to 3500 | 6 | 0.014 | 414 | 0.945 | 184 | 0.420 | 2 | 0.005 | 640 | 1.460 | 70 | 0.160 |
| 3500 to 3750 | 7 | 0.016 | 314 | 0.717 | 302 | 0.689 | 2 | 0.005 | 945 | 2.156 | 31 | 0.071 |
| 3750 to 4000 | 7 | 0.016 | 1623 | 3.703 | 847 | 1.933 | 0 | 0.000 | 2472 | 5.641 | 81 | 0.185 |
| TOTAL | 43 824 | 100 | 43 824 | 100 | 43 824 | 100 | 43 824 | 100 | 43 824 | 100 | 43 824 | 100 |

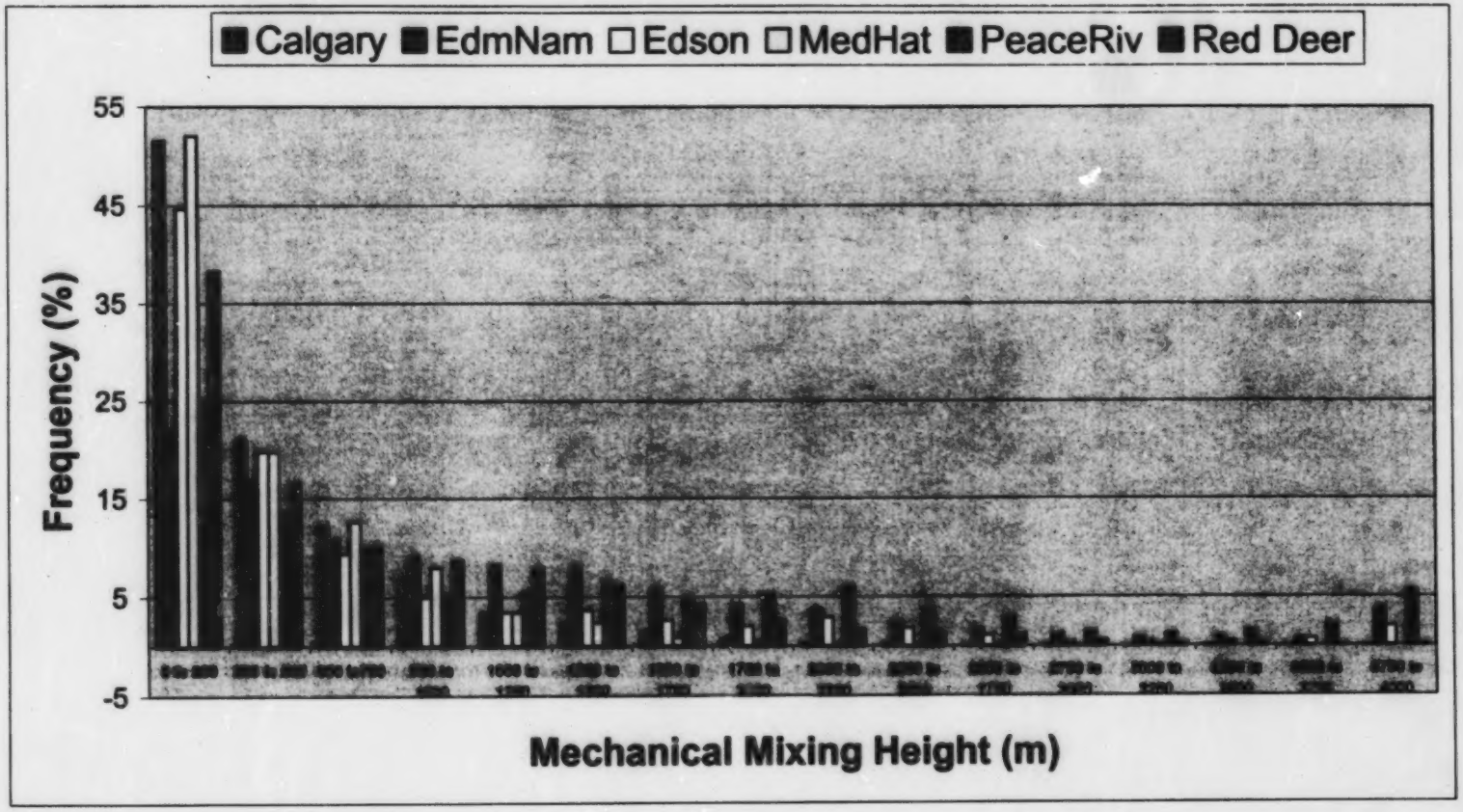


**Figure 5.6 Joint Histogram of the Mechanical Mixing Height Values in the six regional AERMET Meteorology Data Sets**

### *5.1.7 Monin-Obukhov Length – L (m)*

The monin-obukhov length parameter is a measure of atmospheric stability, and is the height at which the generation (or suppression) of thermally generated turbulence by surface heating or cooling, is equal to the generation of turbulence by mechanical means. Negative values are associated with convective atmospheres, and positive values reflect a stable atmosphere. Small negative values are the most convective, and small positive values indicate very stable conditions. Large absolute values (greater than plus or minus 125) are indicative of a neutral atmospheric stability, where almost all of the ground level turbulence is generated by mechanical means.

The Monin-Obukhov length values contained in the AERMET output six regional screening meteorology data sets were analyzed to generate the respective regional frequency distributions. Table 5.9 and Figure 5.7 show the tabular frequency distributions, and the equivalent graphical frequencies in the form of a joint histogram. The most frequent monin-obukhov length range is 10 to 25 m (very stable values) for Calgary (32.69%) and Medicine Hat (41.09%). The other four stations have the most frequent range from 10 to 25 m(frequency's ranging from 16.88% at Red Deer to 41.09% at Edson). This result is similar to those presented in the ERCB study (reference #5), where stable conditions dominated the 10 m observations. The least frequent range of mechanical mixing height values are those from 800 to 900 m (neutral conditions) with all stations having less than a 1.4% frequency.

### *5.1.8 Surface Roughness Length - Zo (m)*

The surface roughness length values contained in the AERMET output six regional screening meteorology data sets were analyzed to generate the respective regional frequency distributions. Table 5.10 and Figure 5.8 show the tabular frequency distributions, and the equivalent graphical frequencies in the form of a joint histogram. For the Calgary and Medicine Hat regions the most frequent surface roughness length range is 0 to 01. m (74.81%). Edson and Peace River have the most frequent range from 1.2 to 1.3 m (25.19%). Edmonton Namao most frequent range is 1.1 to 1.2 m (16.70%), while Red Deer's is 0.5 to 0.6 m (24.92%). Calgary and Medicine Hat have no values in excess of 0.2m. Edson and Peace River have no values less than 0.8m. Edmonton Namao has no values less than 0.4m, while Red Deer has no values less than 0.2 m or greater than 0.8 m. The distribution of the surface roughness values is directly related to the vegetation/landuse category associated numbers quoted in the CTDM Metpro users manual (reference # 2) used as the basis in these calculations.

**Table 5.9 Monin-Obukhov Length Distribution Summary For Each AENV AERMET Regional Meteorology Data Set**

| Monin-Obukhov Length (m) | Station Name | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Calgary | | Edmonton Namao | | Edson | | Medicine Hat | | Peace River | | Red Deer | |
| | Number | (%) | Number | (%) | Number | (%) | Number | (%) | Number | (%) | Number | (%) |
| < -900 | 1411 | 3.220 | 6019 | 13.734 | 3738 | 8.530 | 1154 | 2.633 | 6994 | 15.959 | 3583 | 8.176 |
| -900 to -800 | 201 | 0.459 | 452 | 1.031 | 295 | 0.673 | 149 | 0.340 | 451 | 1.029 | 334 | 0.762 |
| -800 to -600 | 448 | 1.022 | 1018 | 2.323 | 741 | 1.691 | 415 | 0.947 | 1002 | 2.286 | 831 | 1.896 |
| -600 to -400 | 771 | 1.759 | 1529 | 3.489 | 961 | 2.193 | 728 | 1.661 | 1029 | 2.348 | 1345 | 3.069 |
| -400 to -200 | 1823 | 4.160 | 1855 | 4.233 | 1638 | 3.738 | 2124 | 4.847 | 1471 | 3.357 | 2351 | 5.365 |
| -200 to -100 | 2081 | 4.749 | 1539 | 3.512 | 2057 | 4.694 | 2289 | 5.223 | 1437 | 3.279 | 1807 | 4.123 |
| -100 to -50 | 2435 | 5.556 | 1573 | 3.589 | 2379 | 5.429 | 2463 | 5.620 | 1412 | 3.222 | 1564 | 3.569 |
| -50 to -25 | 1819 | 4.151 | 1463 | 3.338 | 2686 | 6.129 | 1524 | 3.478 | 1249 | 2.850 | 1827 | 4.169 |
| -25 to -10 | 1872 | 4.272 | 960 | 2.191 | 2264 | 5.166 | 1656 | 3.779 | 764 | 1.743 | 1942 | 4.431 |
| -10 t 0 | 3107 | 7.090 | 5 | 0.011 | 0 | 0.000 | 3637 | 8.299 | 0 | 0.000 | 684 | 1.561 |
| 0 to 10 | 14325 | 32.688 | 1131 | 2.581 | 68 | 0.155 | 15054 | 34.351 | 294 | 0.671 | 6741 | 15.382 |
| 10 to 25 | 1563 | 3.567 | 7628 | 17.406 | 18007 | 41.089 | 1186 | 2.706 | 10196 | 23.266 | 7398 | 16.881 |
| 25 to 50 | 2270 | 5.180 | 1076 | 2.455 | 1227 | 2.800 | 1829 | 4.174 | 1361 | 3.106 | 1668 | 3.806 |
| 50 to 100 | 3678 | 8.393 | 2914 | 6.649 | 2052 | 4.682 | 3490 | 7.964 | 2331 | 5.319 | 2109 | 4.812 |
| 100 to 200 | 3105 | 7.085 | 3506 | 8.000 | 1751 | 3.996 | 3339 | 7.619 | 2354 | 5.371 | 2538 | 5.791 |
| 200 to 400 | 1831 | 4.178 | 3791 | 8.651 | 1229 | 2.804 | 1932 | 4.409 | 2100 | 4.792 | 2973 | 6.784 |
| 400 to 600 | 554 | 1.264 | 2567 | 5.858 | 687 | 1.568 | 538 | 1.228 | 1656 | 3.779 | 1756 | 4.007 |
| 600 to 800 | 269 | 0.614 | 1557 | 3.553 | 442 | 1.009 | 198 | 0.452 | 1255 | 2.864 | 992 | 2.264 |
| 800 to 900 | 65 | 0.148 | 463 | 1.056 | 256 | 0.584 | 41 | 0.094 | 605 | 1.381 | 267 | 0.609 |
| > 900 | 196 | 0.447 | 2778 | 6.339 | 1346 | 3.071 | 78 | 0.178 | 5863 | 13.379 | 1114 | 2.542 |
| TOTAL | 43 824 | 100 | 43 824 | 100 | 43 824 | 100 | 43 824 | 100 | 43 824 | 100 | 43 824 | 100 |

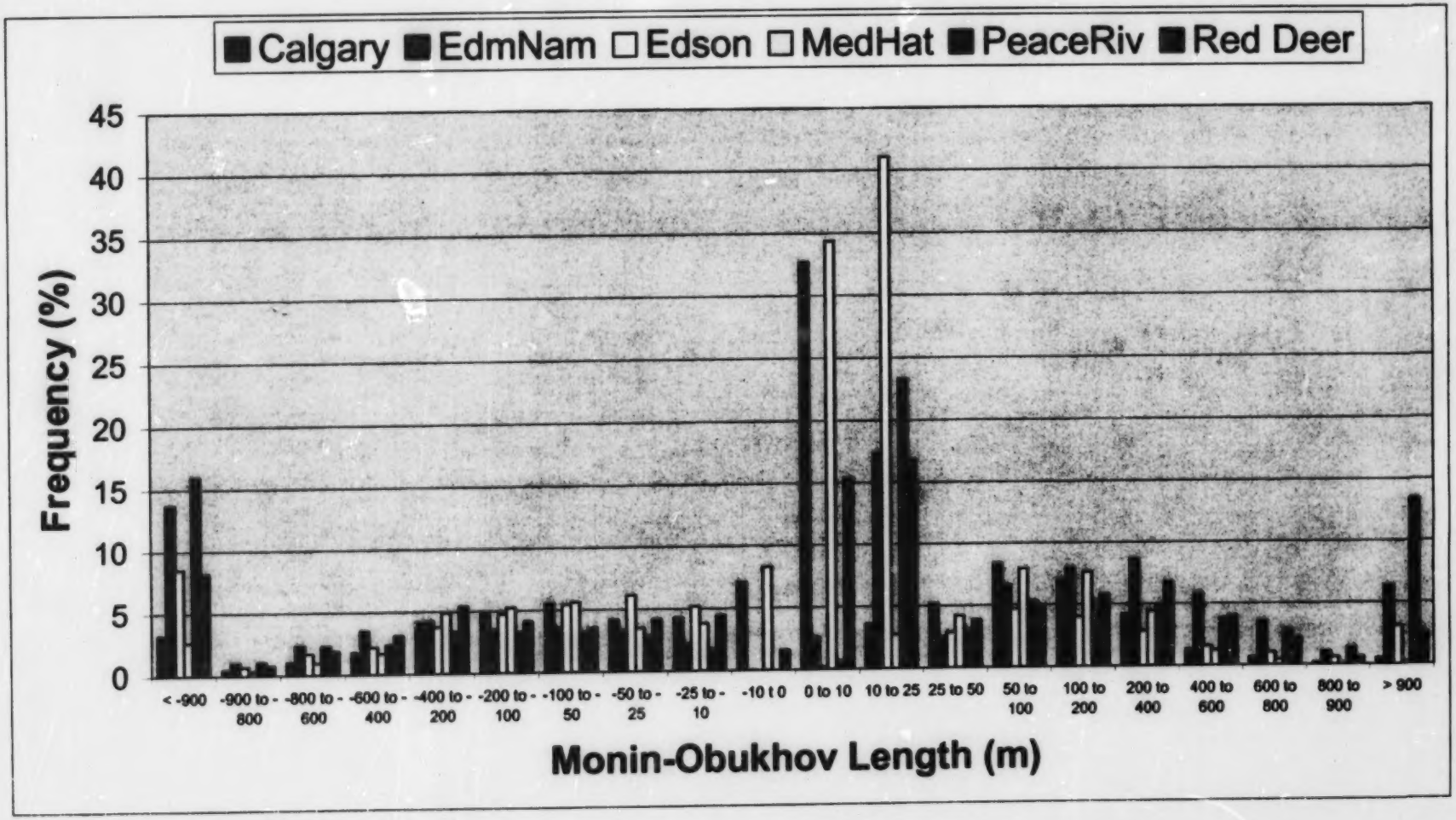


**Figure 5.7 Joint Histogram of the Monin-Obukhov Length values in the six regional AERMET Meteorology Data Sets**

**Table 5.10 Surface Roughness Length Distribution Summary For Each AENV AERMET Regional Meteorology Data Set**

| Surface Roughness Length (m) | Station Name | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Calgary | | Edmonton Namao | | Edson | | Medicine Hat | | Peace River | | Red Deer | |
| | Number | (%) | Number | (%) | Number | (%) | Number | (%) | Number | (%) | Number | (%) |
| 0 to 0.1 | 32784 | 74.808 | 0 | 0.000 | 0 | 0.000 | 32784 | 74.808 | 0 | 0.000 | 0 | 0.000 |
| 0.1 to 0.2 | 11040 | 25.192 | 0 | 0.000 | 0 | 0.000 | 11040 | 25.192 | 0 | 0.000 | 0 | 0.000 |
| 0.2 to 0.3 | 0 | 0.000 | 0 | 0.000 | 0 | 0.000 | 0 | 0.000 | 0 | 0.000 | 3720 | 8.488 |
| 0.3 to 0.4 | 0 | 0.000 | 0 | 0.000 | 0 | 0.000 | 0 | 0.000 | 0 | 0.000 | 10704 | 24.425 |
| 0.4 to 0.5 | 0 | 0.000 | 3720 | 8.488 | 0 | 0.000 | 0 | 0.000 | 0 | 0.000 | 7440 | 16.977 |
| 0.5 to 0.6 | 0 | 0.000 | 3720 | 8.488 | 0 | 0.000 | 0 | 0.000 | 0 | 0.000 | 10920 | 24.918 |
| 0.6 to 0.7 | 0 | 0.000 | 6984 | 15.936 | 0 | 0.000 | 0 | 0.000 | 0 | 0.000 | 7320 | 16.703 |
| 0.7 to 0.8 | 0 | 0.000 | 3720 | 8.488 | 0 | 0.000 | 0 | 0.000 | 0 | 0.000 | 3720 | 8.488 |
| 0.8 to 0.9 | 0 | 0.000 | 3720 | 8.488 | 3720 | 8.488 | 0 | 0.000 | 3720 | 8.488 | 0 | 0.000 |
| 0.9 to 1.0 | 0 | 0.000 | 7200 | 16.429 | 10704 | 24.425 | 0 | 0.000 | 10704 | 24.425 | 0 | 0.000 |
| 1.0 to 1.1 | 0 | 0.000 | 3720 | 8.488 | 7440 | 16.977 | 0 | 0.000 | 7440 | 16.977 | 0 | 0.000 |
| 1.1 to 1.2 | 0 | 0.000 | 7320 | 16.703 | 10920 | 24.918 | 0 | 0.000 | 10920 | 24.918 | 0 | 0.000 |
| 1.2 to 1.3 | 0 | 0.000 | 3720 | 8.488 | 11040 | 25.192 | 0 | 0.000 | 11040 | 25.192 | 0 | 0.000 |
| TOTAL | 43 824 | 100 | 43 824 | 100 | 43 824 | 100 | 43 824 | 100 | 43 824 | 100 | 43 824 | 100 |

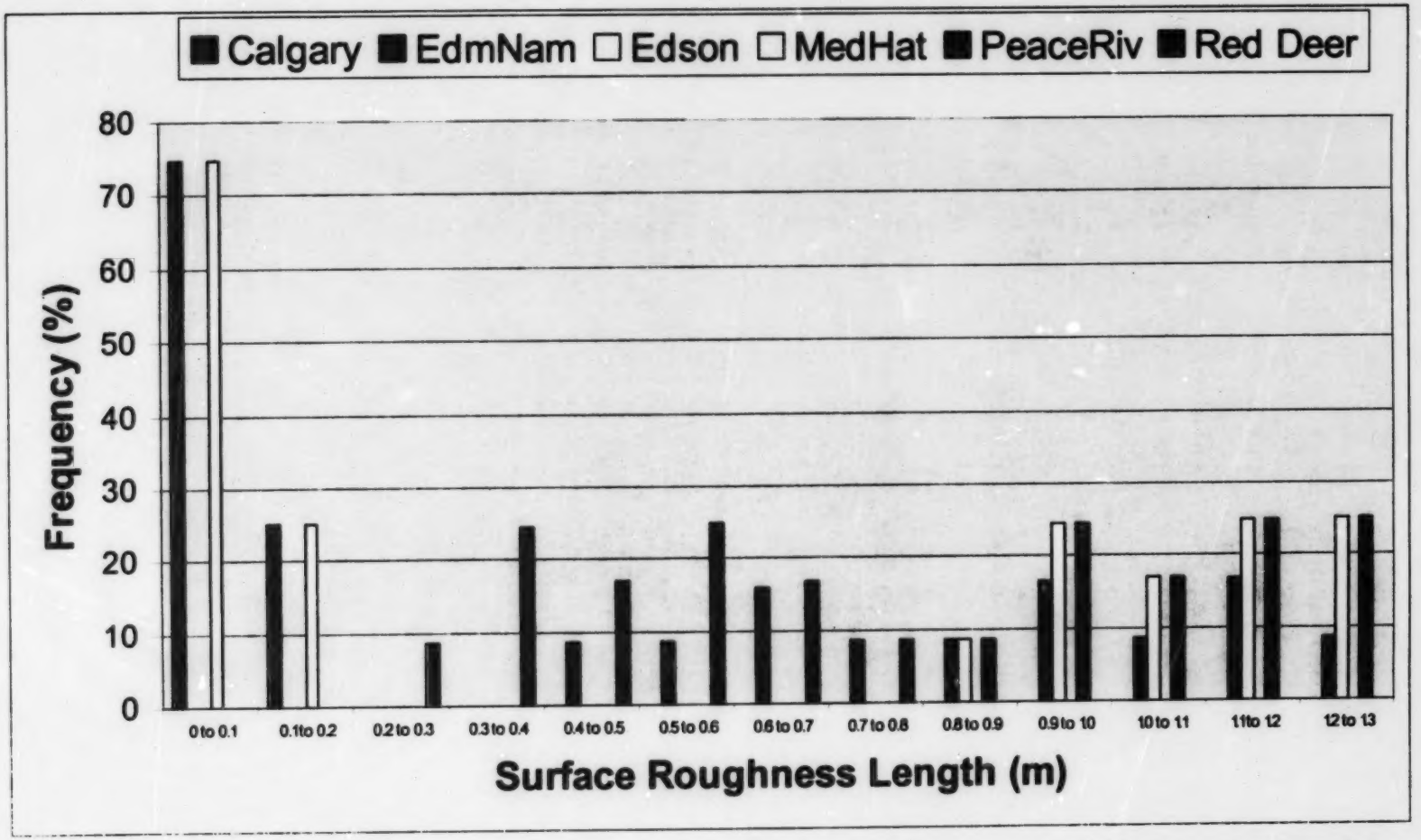


**Figure 5.8** **Joint Histogram of the Surface Roughness Length Values in the Six Regional AERMET Meteorology Data Sets**

### *5.1.9 Bowen Ratio – BR (dimensionless)*

The bowen ratio values contained in the AERMET output six regional screening meteorology data sets were analyzed to generate the respective regional frequency distributions. Table 5.11 and Figure 5.9 show the tabular frequency distributions and the equivalent graphical frequencies in the form of a joint histogram. For the Calgary and Medicine Hat regions the most frequent bowen ratio range is 0.7 to 0.8 (25.19%). Edson and Peace River have the most frequent range from 0.4 to 0.5 (16.70%). Edmonton Namao most frequent ranges is 0.5 to 0.6 and 0.9 to 1.0 (16.98%), while Red Deer's is 0.4 to 0.5 and 0.5 to 0.6 (16.70%). Calgary and Medicine Hat have no values in less than 0.3, and no values in the 0.9 to 1.0 and 1.3 to 1.4 ranges. Edson and Peace River have no values less than 0.2, and no values in the ranges 0.3 to 0.4, 0.7 to 0.8, 1.1 to 1.2, and 1.3 to 1.4. Edmonton Namao has no values less than 0.2, and in the ranges 0.3 to 0.4, 0.8 to 0.9, and 1.0 to 1.1, while Red Deer has no values less than 0.4, and no values in the ranges 1.0 to 1.1, and 1.2 to 1.3. The distribution of the bowen ration values is directly related to the vegetation/landuse category associated values quoted in the CTDM Metpro users manual (reference # 2) used as a basis in these calculations.

### *5.1.10 Albedo – A (% reflection)*

The albedo ratio values contained in the AERMET output six regional screening meteorology data sets were analyzed to generate the respective regional frequency distributions. Table 5.12 and Figure 5.10 show the tabular frequency distributions, and the equivalent graphical frequencies in the form of a joint histogram. The most frequent albedo range is 0.9 to 1.0 for all six regional data sets (frequency's ranging from 49.75% at Edmonton Namao to 50.15% at Calgary). The least frequent range of albedo values are those from 0.0 to 0.1 with no reported data in any of the six regions. The distribution of the albedo values is directly related to the vegetation/landuse category associated values quoted in the CTDM Metpro users manual (reference # 2) used in the basis of these calculations.

### *5.1.11 Wind Speed – WS (m/s)*

The wind speed values contained in the AERMET output six regional screening meteorology data sets were analyzed to generate the respective regional frequency distributions. Table 5.13 and Figure 5.11 show the tabular frequency distributions, and the equivalent graphical frequencies in the form of a joint histogram. The most frequent wind speed range is the 0 to 1 m/s. Which in this case indicates the minimum wind speed value of 1.0 m/s. The frequency of 1.0 m/s wind speeds ranges from 29.65% at Edmonton Namao to 64.49% at Edson. The least frequent wind speed range are those in excess of 20 m/s with only 2 values observed at Calgary.

**Table 5.11 MidDay Bowen Ratio Distribution Summary For Each AENV AERMET Regional Meteorology Data Set**

| MidDay Bowen Ratio | Station Name | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Calgary | | Edmonton Namao | | Edson | | Medicine Hat | | Peace River | | Red Deer | |
| | Number | (%) | Number | (%) | Number | (%) | Number | (%) | Number | (%) | Number | (%) |
| 0 to 0.1 | 0 | 0.000 | 0 | 0.000 | 0 | 0.000 | 0 | 0.000 | 0 | 0.000 | 0 | 0.000 |
| 0.1 to 0.2 | 0 | 0.000 | 0 | 0.000 | 0 | 0.000 | 0 | 0.000 | 0 | 0.000 | 0 | 0.000 |
| 0.2 to 0.3 | 0 | 0.000 | 3720 | 8.488 | 3720 | 8.488 | 0 | 0.000 | 3720 | 8.488 | 0 | 0.000 |
| 0.3 to 0.4 | 3600 | 8.215 | 0 | 0.000 | 0 | 0.000 | 3600 | 8.215 | 0 | 0.000 | 0 | 0.000 |
| 0.4 to 0.5 | 3720 | 8.488 | 3600 | 8.215 | 7320 | 16.703 | 3720 | 8.488 | 7320 | 16.703 | 7320 | 16.703 |
| 0.5 to 0.6 | 3600 | 8.215 | 7440 | 16.977 | 3720 | 8.488 | 3600 | 8.215 | 3720 | 8.488 | 7320 | 16.703 |
| 0.6 to 0.7 | 3720 | 8.488 | 3600 | 8.215 | 7200 | 16.429 | 3720 | 8.488 | 7200 | 16.429 | 3720 | 8.488 |
| 0.7 to 0.8 | 11040 | 25.192 | 3600 | 8.215 | 0 | 0.000 | 11040 | 25.192 | 0 | 0.000 | 3600 | 8.215 |
| 0.8 to 0.9 | 3720 | 8.488 | 0 | 0.000 | 3720 | 8.488 | 3720 | 8.488 | 3720 | 8.488 | 3720 | 8.488 |
| 0.9 to 1.0 | 0 | 0.000 | 7440 | 16.977 | 3720 | 8.488 | 0 | 0.000 | 3720 | 8.488 | 3720 | 8.488 |
| 1.0 to 1.1 | 3600 | 8.215 | 0 | 0.000 | 3600 | 8.215 | 3600 | 8.215 | 3600 | 8.215 | 0 | 0.000 |
| 1.1 to 1.2 | 3384 | 7.722 | 3600 | 8.215 | 0 | 0.000 | 3384 | 7.722 | 0 | 0.000 | 6984 | 15.936 |
| 1.2 to 1.3 | 3720 | 8.488 | 3384 | 7.722 | 7104 | 16.210 | 3720 | 8.488 | 7104 | 16.210 | 0 | 0.000 |
| 1.3 to 1.4 | 0 | 0.000 | 3720 | 8.488 | 0 | 0.000 | 0 | 0.000 | 0 | 0.000 | 3720 | 8.488 |
| 1.4 to 1.5 | 3720 | 8.488 | 3720 | 8.488 | 3720 | 8.488 | 3720 | 8.488 | 3720 | 8.488 | 3720 | 8.488 |
| TOTAL | 43 824 | 100 | 43 824 | 100 | 43 824 | 100 | 43 824 | 100 | 43 824 | 100 | 43 824 | 100 |

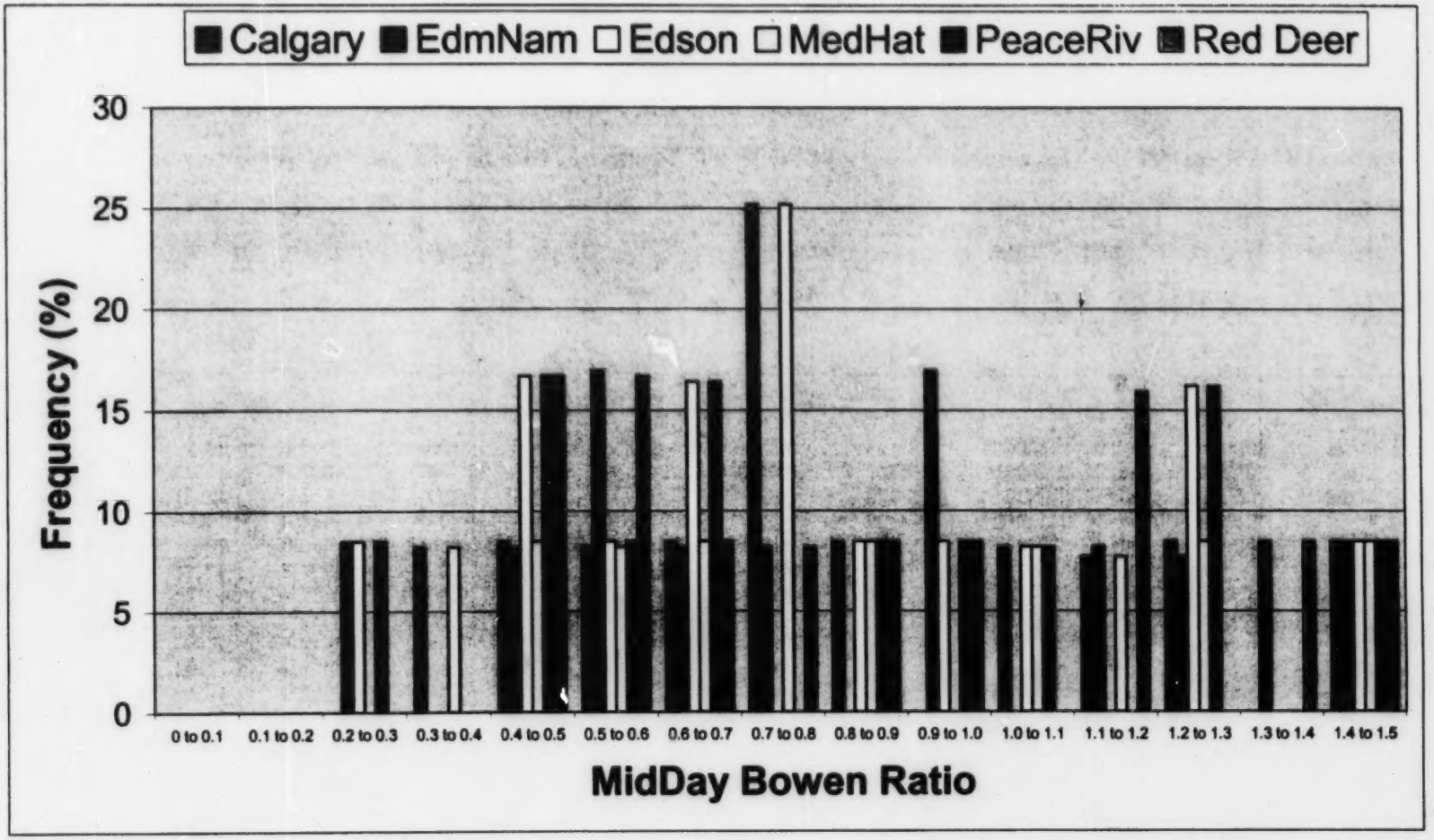


**Figure 5.9 Joint Histogram of the MidDay Bowen Ration values in the six regional AERMET Meteorology Data Sets**

**Table 5.12 Surface Albedo Distribution Summary For Each AENV AERMET Regional Meteorology Data Set**

| Surface Albedo | Station Name | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Calgary | | Edmonton Namao | | Edson | | Medicine Hat | | Peace River | | Red Deer | |
| | Number | (%) | Number | (%) | Number | (%) | Number | (%) | Number | (%) | Number | (%) |
| 0 to 0.1 | 0 | 0.000 | 0 | 0.000 | 0 | 0.000 | 0 | 0.000 | 0 | 0.000 | 0 | 0.000 |
| 0.1 to 0.2 | 4782 | 10.912 | 10255 | 23.400 | 10260 | 23.412 | 4839 | 11.042 | 10092 | 23.028 | 8471 | 19.330 |
| 0.2 to 0.3 | 6033 | 13.766 | 2924 | 6.672 | 3196 | 7.293 | 6007 | 13.707 | 3206 | 7.316 | 3169 | 7.231 |
| 0.3 to 0.4 | 1980 | 4.518 | 2149 | 4.904 | 2521 | 5.753 | 2049 | 4.676 | 2382 | 5.435 | 2864 | 6.535 |
| 0.4 to 0.5 | 2742 | 6.257 | 2168 | 4.947 | 2131 | 4.863 | 2657 | 6.063 | 1955 | 4.461 | 2006 | 4.577 |
| 0.5 to 0.6 | 2239 | 5.109 | 1879 | 4.288 | 2033 | 4.639 | 2226 | 5.079 | 2166 | 4.942 | 2194 | 5.006 |
| 0.6 to 0.7 | 1826 | 4.167 | 1762 | 4.021 | 1191 | 2.718 | 1917 | 4.374 | 1494 | 3.409 | 1915 | 4.370 |
| 0.7 to 0.8 | 1531 | 3.494 | 529 | 1.207 | 525 | 1.198 | 1665 | 3.799 | 487 | 1.111 | 771 | 1.759 |
| 0.8 to 0.9 | 715 | 1.632 | 356 | 0.812 | 200 | 0.456 | 508 | 1.159 | 215 | 0.491 | 513 | 1.171 |
| 0.9 to 1.0 | 21976 | 50.146 | 21802 | 49.749 | 21767 | 49.669 | 21956 | 50.100 | 21827 | 49.806 | 21921 | 50.021 |
| TOTAL | 43 824 | 100 | 43 824 | 100 | 43 824 | 100 | 43 824 | 100 | 43 824 | 100 | 43 824 | 100 |

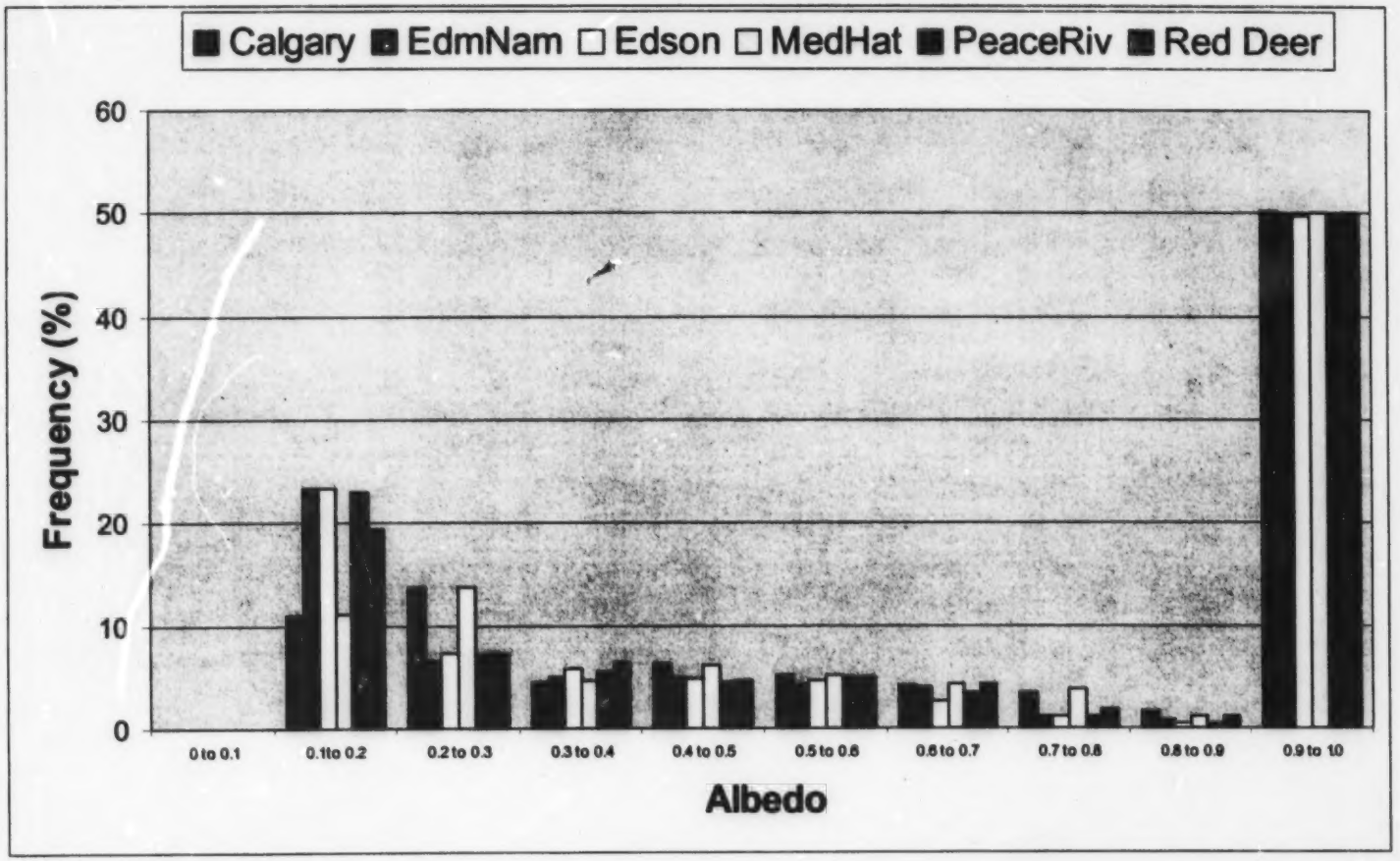


**Figure 5.10 Joint Histogram of the Surface Albedo Values in the Six Regional AERMET Meteorology Data Sets**

**Table 5.13 Wind Speed Distribution Summary For Each AENV AERMET Regional Meteorology Data Set**

| Wind Speed Range (m/s) | Station Name | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Calgary | | Edmonton Namao | | Edson | | Medicine Hat | | Peace River | | Red Deer | |
| | Number | (%) | Number | (%) | Number | (%) | Number | (%) | Number | (%) | Number | (%) |
| 0 to 1 | 13527 | 30.867 | 12992 | 29.646 | 28264 | 64.494 | 15684 | 35.789 | 15519 | 35.412 | 16986 | 38.760 |
| 1 to 2 | 8366 | 19.090 | 9919 | 22.634 | 7068 | 16.128 | 6887 | 15.715 | 8334 | 19.017 | 9026 | 20.596 |
| 2 to 3 | 3776 | 8.616 | 4088 | 9.328 | 1772 | 4.043 | 2400 | 5.476 | 3101 | 7.076 | 3455 | 7.884 |
| 3 to 4 | 5715 | 13.041 | 7069 | 16.130 | 2153 | 4.913 | 4513 | 10.298 | 4555 | 10.394 | 4767 | 10.878 |
| 4 to 5 | 5833 | 13.310 | 5692 | 12.988 | 2862 | 6.531 | 7594 | 17.328 | 6788 | 15.489 | 6047 | 13.798 |
| 5 to 6 | 1275 | 2.909 | 859 | 1.960 | 236 | 0.539 | 857 | 1.956 | 1099 | 2.508 | 1019 | 2.325 |
| 6 to 7 | 2028 | 4.628 | 1504 | 3.432 | 861 | 1.965 | 3419 | 7.802 | 3052 | 6.964 | 1857 | 4.237 |
| 7 to 8 | 1731 | 3.950 | 1101 | 2.512 | 411 | 0.938 | 1413 | 3.224 | 1029 | 2.348 | 489 | 1.116 |
| 8 to 9 | 641 | 1.463 | 330 | 0.753 | 143 | 0.326 | 565 | 1.289 | 250 | 0.570 | 114 | 0.260 |
| 9 to 10 | 189 | 0.431 | 29 | 0.066 | 6 | 0.014 | 36 | 0.082 | 13 | 0.030 | 14 | 0.032 |
| 10 to 11 | 418 | 0.954 | 171 | 0.390 | 35 | 0.080 | 260 | 0.593 | 58 | 0.132 | 28 | 0.064 |
| 11 to 12 | 157 | 0.358 | 45 | 0.103 | 10 | 0.023 | 102 | 0.233 | 23 | 0.052 | 16 | 0.037 |
| 12 to 13 | 37 | 0.084 | 5 | 0.011 | 1 | 0.002 | 21 | 0.048 | 1 | 0.002 | 4 | 0.009 |
| 13 to 14 | 60 | 0.137 | 15 | 0.034 | 1 | 0.002 | 32 | 0.073 | 1 | 0.002 | 1 | 0.002 |
| 14 to 15 | 34 | 0.078 | 2 | 0.005 | 1 | 0.002 | 26 | 0.059 | 1 | 0.002 | 1 | 0.002 |
| 15 to 16 | 20 | 0.046 | 2 | 0.005 | 0 | 0.000 | 11 | 0.025 | 0 | 0.000 | 0 | 0.000 |
| 16 to 17 | 3 | 0.007 | 0 | 0.000 | 0 | 0.000 | 1 | 0.002 | 0 | 0.000 | 0 | 0.000 |
| 17 to 18 | 8 | 0.018 | 0 | 0.000 | 0 | 0.000 | 3 | 0.007 | 0 | 0.000 | 0 | 0.000 |
| 18 to 19 | 4 | 0.009 | 1 | 0.002 | 0 | 0.000 | 0 | 0.000 | 0 | 0.000 | 0 | 0.000 |
| 19 to 20 | 0 | 0.000 | 0 | 0.000 | 0 | 0.000 | 0 | 0.000 | 0 | 0.000 | 0 | 0.000 |
| >20 | 2 | 0.005 | 0 | 0.000 | 0 | 0.000 | 0 | 0.000 | 0 | 0.000 | 0 | 0.000 |
| TOTAL | 43 824 | 100 | 43 824 | 100 | 43 824 | 100 | 43 824 | 100 | 43 824 | 100 | 43 824 | 100 |

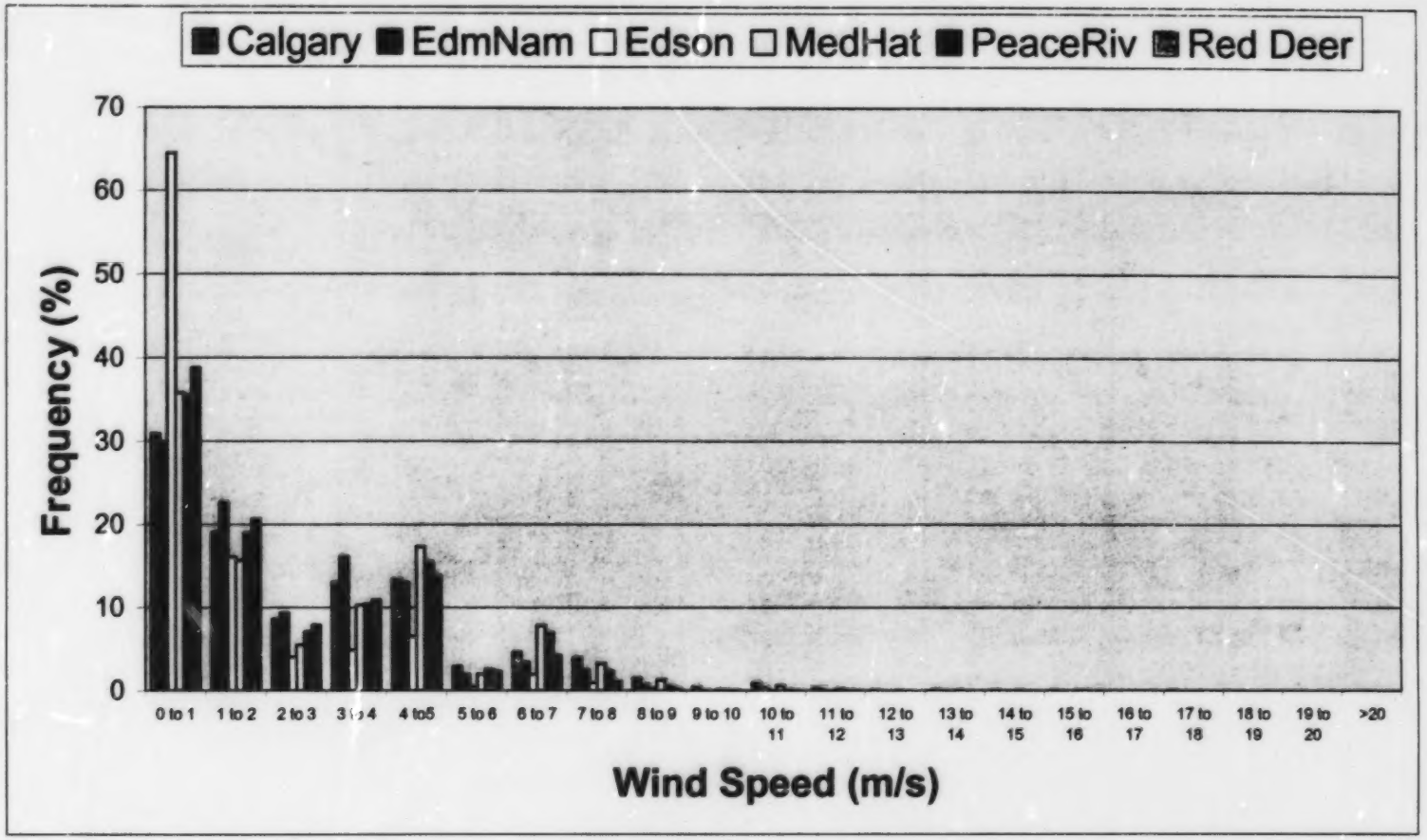


**Figure 5.11 Joint Histogram of the Wind Speed Values in the Six Regional AERMET Meteorology Data Sets**

### *5.1.12 Wind Direction – WD (degrees from which wind is blowing)*

The wind direction values contained in the AERMET output six regional screening meteorology data sets were analyzed to generate the respective regional frequency distributions. Table 5.14 and Figure 5.12 show the tabular frequency distributions, and the equivalent graphical frequencies in the form of a joint histogram. The most frequent wind direction sectors at the regional sites are Calgary - NNW, Edmonton Namao - W, Edson - W, Medicine Hat - SW, Peace River - SW, and Red Deer –S. The least frequent wind direction sectors at the regional sites are Calgary - ENE, Edmonton Namao - NE, Edson - SSE, Medicine Hat - SE, Peace River - ESE, and Red Deer –ENE.

Figures 5.14 to 5.19 illustrate the surface data windroses for the six AEVN regional data sets. The windroses depict the distribution of wind direction 'from which the wind is blowing', which is the usual convention for these type of meteorological depictions. Since all wind speeds less than 1 m/s were replaced as part of the QA/QC procedure, no calms are found in these windroses (which typically indicate the frequency of calm conditions). A summary of the six regional windroses is presented in the following points:

- The Calgary windrose show that the dominant wind directions are those from the north, and north-north-west (> 9%), and the least frequent winds are from the northeast to east sectors (<4%).

- For the Edmonton Namao location the windrose is dominated by winds from the west-north-west, west, and west-south-west directions (>9%). The least frequent wind are in the north-north-east and northeast sectors (<4%).

- The Edson windrose is dominated by winds from the west-northwest to west sectors (>14%), with the least frequent wind directions coming from the north and south directions (<2%).

- At Medicine Hat the most frequent winds are from the southwest sector (>19%), and the least frequent from the south-south-east to east-south-east directions (<<3%).

- The west to southwest sectors (>>12%) dominate the Peace River windrose, with the least frequent wind directions coming from south-south-east to east-south-east directions (<<3%).

- At Red Deer the most frequent wind directions are from the south and south-south-west(>10%), with the least frequent coming from the east to northeast sectors(<4%).

## Table 5.14 Wind Direction Distribution Summary For Each AENV AERMET Regional Meteorology Data Set

| Wind Direction Range (sector) | Station Name | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Calgary | | Edmonton Namao | | Edson | | Medicine Hat | | Peace River | | Red Deer | |
| | Number | (%) | Number | (%) | Number | (%) | Number | (%) | Number | (%) | Number | (%) |
| N | 4269 | 9.741 | 2010 | 4.587 | 1076 | 2.455 | 1943 | 4.434 | 3798 | 8.666 | 2601 | 5.935 |
| NNE | 2124 | 4.847 | 1436 | 3.277 | 1464 | 3.341 | 2163 | 4.936 | 3678 | 8.393 | 2013 | 4.593 |
| NE | 1736 | 3.961 | 1288 | 2.939 | 2237 | 5.105 | 1960 | 4.472 | 3022 | 6.896 | 1535 | 3.503 |
| ENE | 1280 | 2.921 | 1519 | 3.466 | 3508 | 8.005 | 2224 | 5.075 | 2079 | 4.744 | 1400 | 3.195 |
| E | 1577 | 3.598 | 2027 | 4.625 | 2571 | 5.867 | 2520 | 5.750 | 1577 | 3.598 | 1414 | 3.227 |
| ESE | 1741 | 3.973 | 2369 | 5.406 | 1560 | 3.560 | 1196 | 2.729 | 1133 | 2.585 | 1553 | 3.544 |
| SE | 2666 | 6.083 | 2419 | 5.520 | 1258 | 2.871 | 1010 | 2.305 | 1178 | 2.688 | 3113 | 7.103 |
| SSE | 3568 | 8.142 | 2531 | 5.775 | 1002 | 2.286 | 1156 | 2.638 | 1384 | 3.158 | 4025 | 9.184 |
| S | 3718 | 8.484 | 2652 | 6.051 | 1098 | 2.505 | 1755 | 4.005 | 2226 | 5.079 | 5265 | 12.014 |
| SSW | 3564 | 8.133 | 2896 | 6.608 | 1291 | 2.946 | 3440 | 7.850 | 3573 | 8.153 | 4570 | 10.428 |
| SW | 2494 | 5.691 | 3670 | 8.374 | 1985 | 4.529 | 8613 | 19.654 | 4796 | 10.944 | 2738 | 6.248 |
| WSW | 1884 | 4.299 | 3950 | 9.013 | 5041 | 11.503 | 5158 | 11.770 | 4319 | 9.855 | 2010 | 4.587 |
| W | 3360 | 7.667 | 4832 | 11.026 | 8418 | 19.209 | 3404 | 7.767 | 4164 | 9.502 | 2242 | 5.116 |
| WNW | 1744 | 3.980 | 4024 | 9.182 | 6452 | 14.723 | 2502 | 5.709 | 2229 | 5.086 | 2524 | 5.759 |
| NW | 3234 | 7.380 | 3387 | 7.729 | 3188 | 7.275 | 2453 | 5.597 | 1920 | 4.381 | 3363 | 7.674 |
| NNW | 4865 | 11.101 | 2814 | 6.421 | 1675 | 3.822 | 2327 | 5.310 | 2748 | 6.271 | 3458 | 7.891 |
| TOTAL | 43 824 | 100 | 43 824 | 100 | 43 824 | 100 | 43 824 | 100 | 43 824 | 100 | 43 824 | 100 |

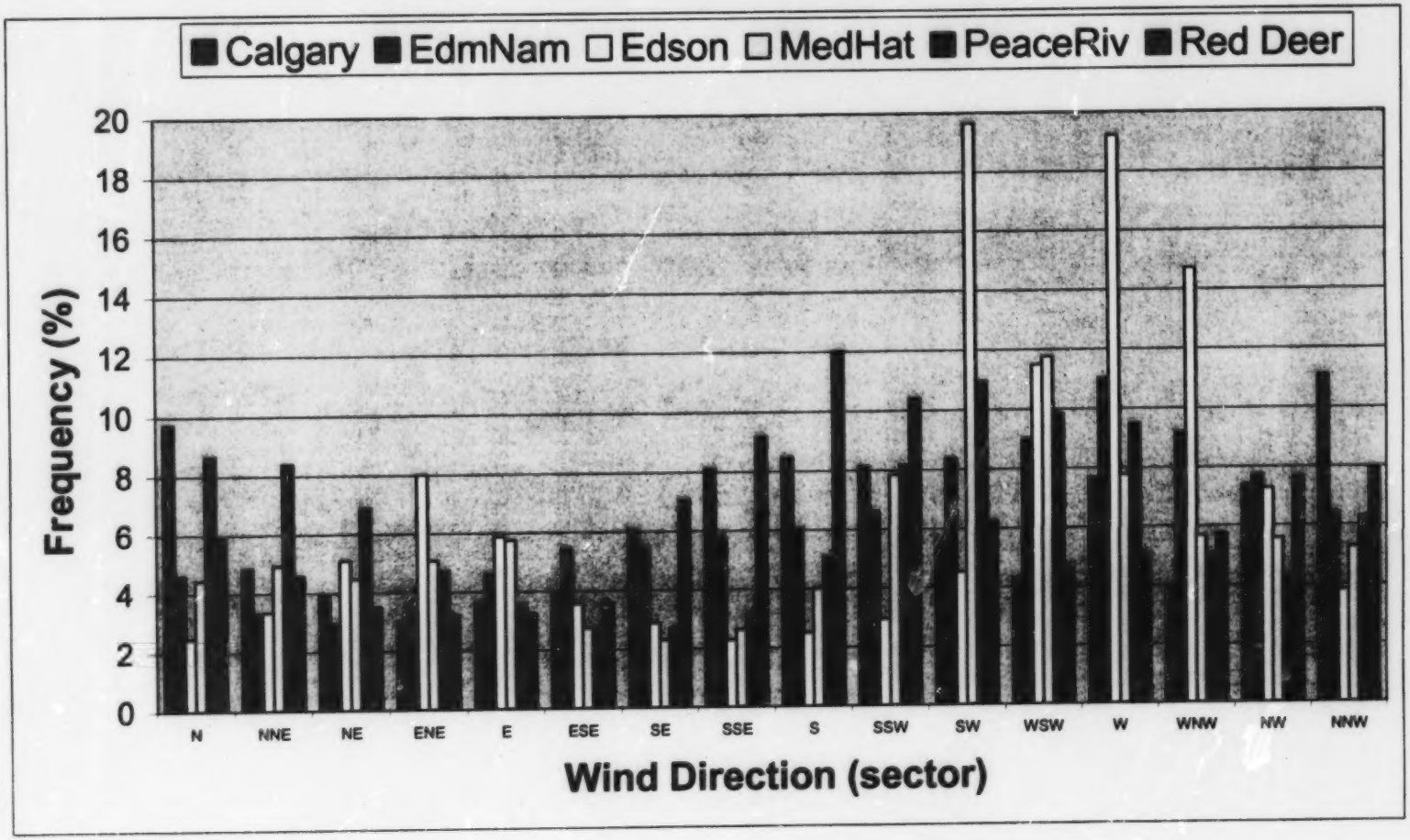


**Figure 5.12 Joint Histogram of the Wind Direction Values in the Six Regional AERMET Meteorology Data Sets**

### *5.1.13 Ambient Temperature – T (degrees K)*

The ambient temperature values contained in the AERMET output six regional screening meteorology data sets were analyzed to generate the respective regional frequency distributions. Table 5.15 and Figure 5.13 show the tabular frequency distributions, and the equivalent graphical frequencies in the form of a joint histogram. The most frequent ambient temperature range is 270 to 280 degrees K for all six regional data sets (frequency's ranging from 28.101% at Peace River to 34.31% at Edson). The least frequent range of ambient temperature values are those from 220 to 230 degrees K with only 12 values, and > 320 degrees K with no reported values.

## Table 5.15 Ambient Temperature Distribution Summary For Each AENV AERMET Regional Meteorology Data Set

| Ambient Temperature Range (degree K) | Station Name | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Calgary | | Edmonton Namao | | Edson | | Medicine Hat | | Peace River | | Red Deer | |
| | Number | (%) | Number | (%) | Number | (%) | Number | (%) | Number | (%) | Number | (%) |
| 220 to 230 | 0 | 0.000 | 0 | 0.000 | 9 | 0.021 | 0 | 0.000 | 3 | 0.007 | 0 | 0.000 |
| 230 to 240 | 52 | 0.119 | 30 | 0.068 | 185 | 0.422 | 100 | 0.228 | 500 | 1.141 | 234 | 0.534 |
| 240 to 250 | 938 | 2.140 | 1111 | 2.535 | 799 | 1.823 | 1100 | 2.510 | 2032 | 4.637 | 1308 | 2.985 |
| 250 to 260 | 3617 | 8.253 | 3518 | 8.028 | 3372 | 7.694 | 3762 | 8.584 | 5322 | 12.144 | 4873 | 11.119 |
| 260 to 270 | 6864 | 15.663 | 7104 | 16.210 | 8352 | 19.058 | 5891 | 13.442 | 7269 | 16.587 | 7448 | 16.995 |
| 270 to 280 | 14567 | 33.240 | 13956 | 31.846 | 15034 | 34.305 | 13010 | 29.687 | 12314 | 28.099 | 13604 | 31.042 |
| 280 to 290 | 12871 | 29.370 | 13177 | 30.068 | 12201 | 27.841 | 12683 | 28.941 | 12337 | 28.151 | 12285 | 28.033 |
| 290 to 300 | 4686 | 10.693 | 4793 | 10.937 | 3780 | 8.625 | 6392 | 14.586 | 4002 | 9.132 | 3955 | 9.025 |
| 300 to 310 | 229 | 0.523 | 135 | 0.308 | 92 | 0.210 | 886 | 2.022 | 45 | 0.103 | 117 | 0.267 |
| 310 to 320 | 0 | 0.000 | 0 | 0.000 | 0 | 0.000 | 0 | 0.000 | 0 | 0.000 | 0 | 0.000 |
| TOTAL | 43 824 | 100 | 43 824 | 100 | 43 824 | 100 | 43 824 | 100 | 43 824 | 100 | 43 824 | 100 |

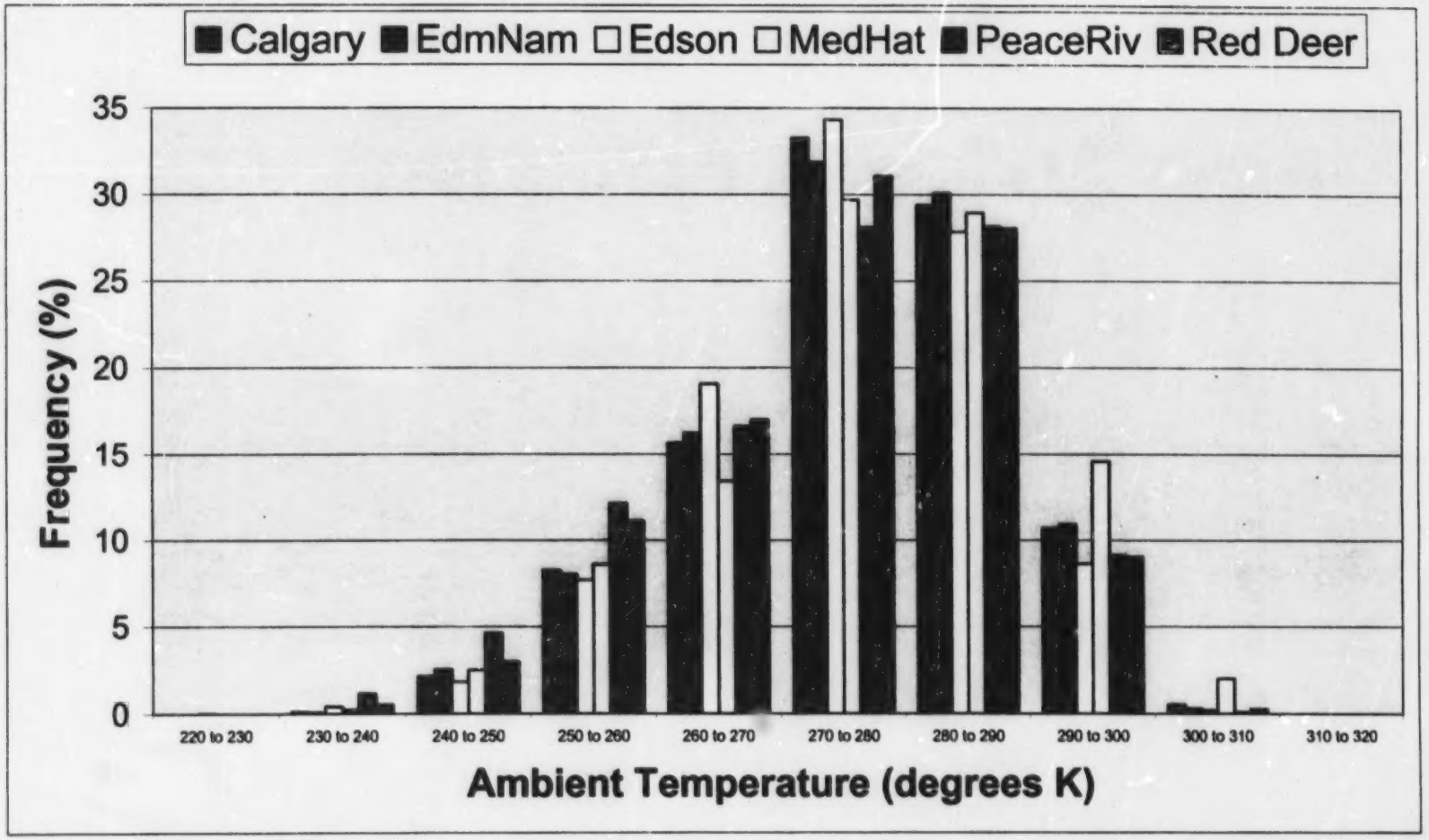


**Figure 5.13 Joint Histogram of the Ambient Temperature values in the six regional AERMET Meteorology Data Sets**

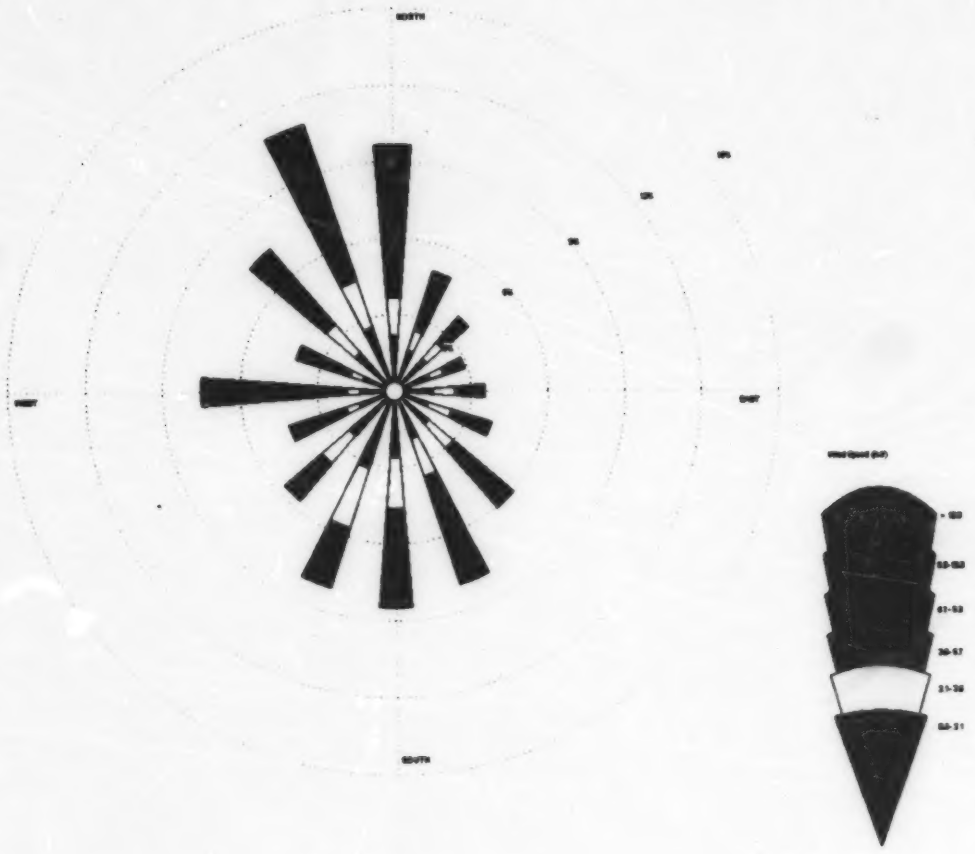

**Figure 5.14 Wind Rose for the Calgary Bow Region AERMET Meteorology Data Set (1994 to 1998)**

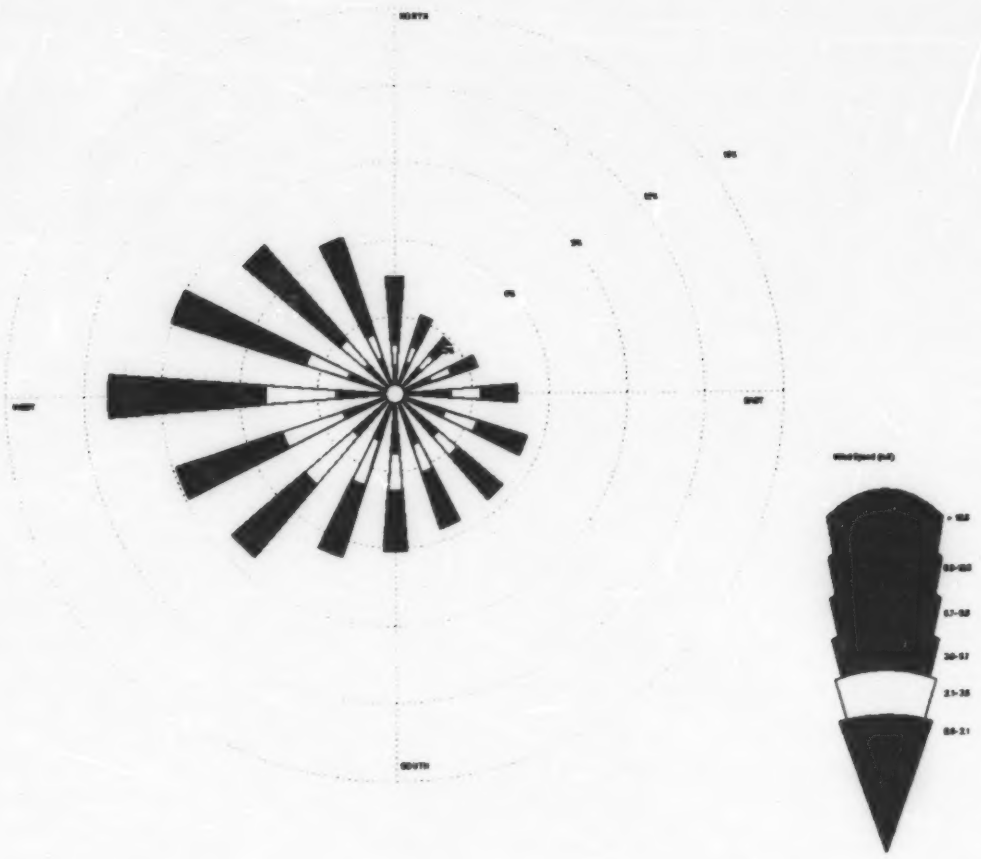

**Figure 5.15 Wind Rose for the Edmonton Namao Northeast Boreal Region AERMET Meteorology Data Set (1990 to 1994)**

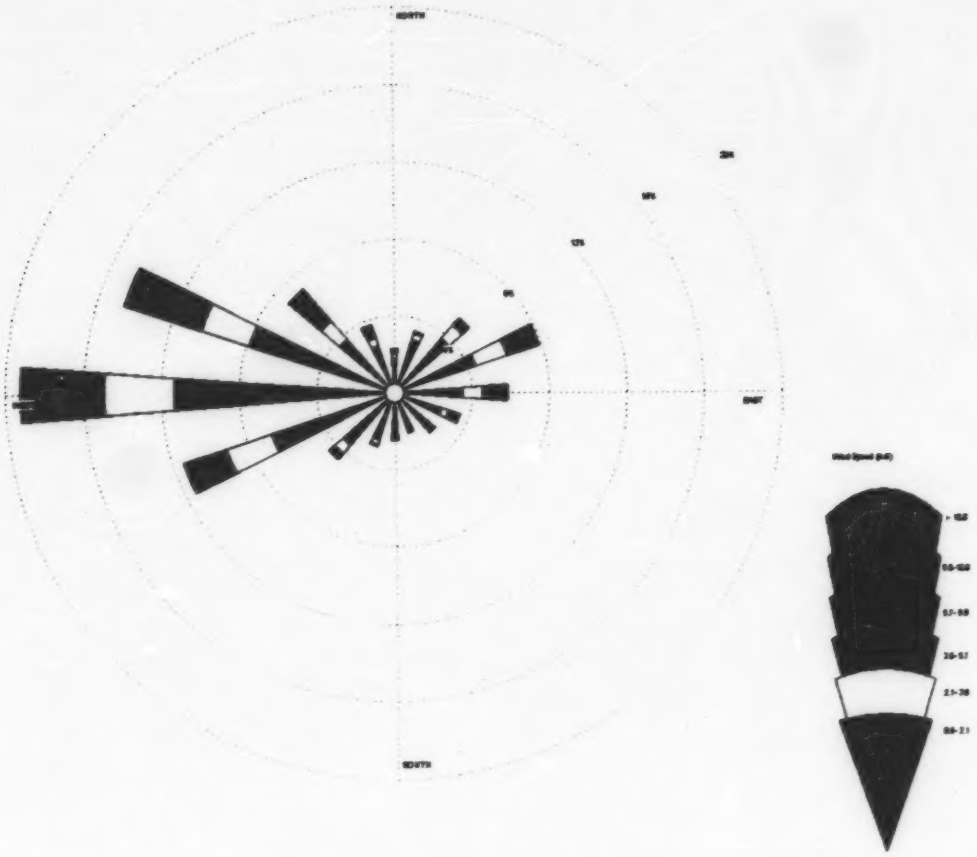

**Figure 5.16 Wind Rose for the Edson North East Slope Region AERMET Meteorology Data Set (1986 to 1990)**

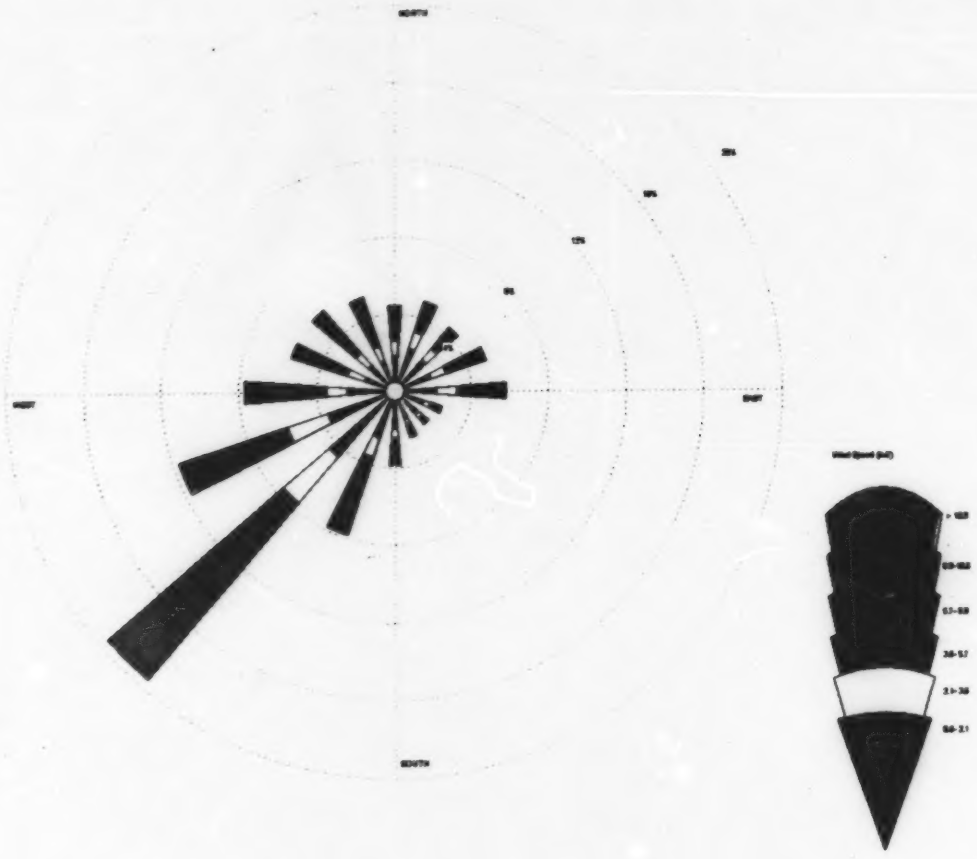

**Figure 5.17 Wind Rose for the Medicine Hat Prairie Region AERMET Meteorology Data Set (1993 to 1997)**

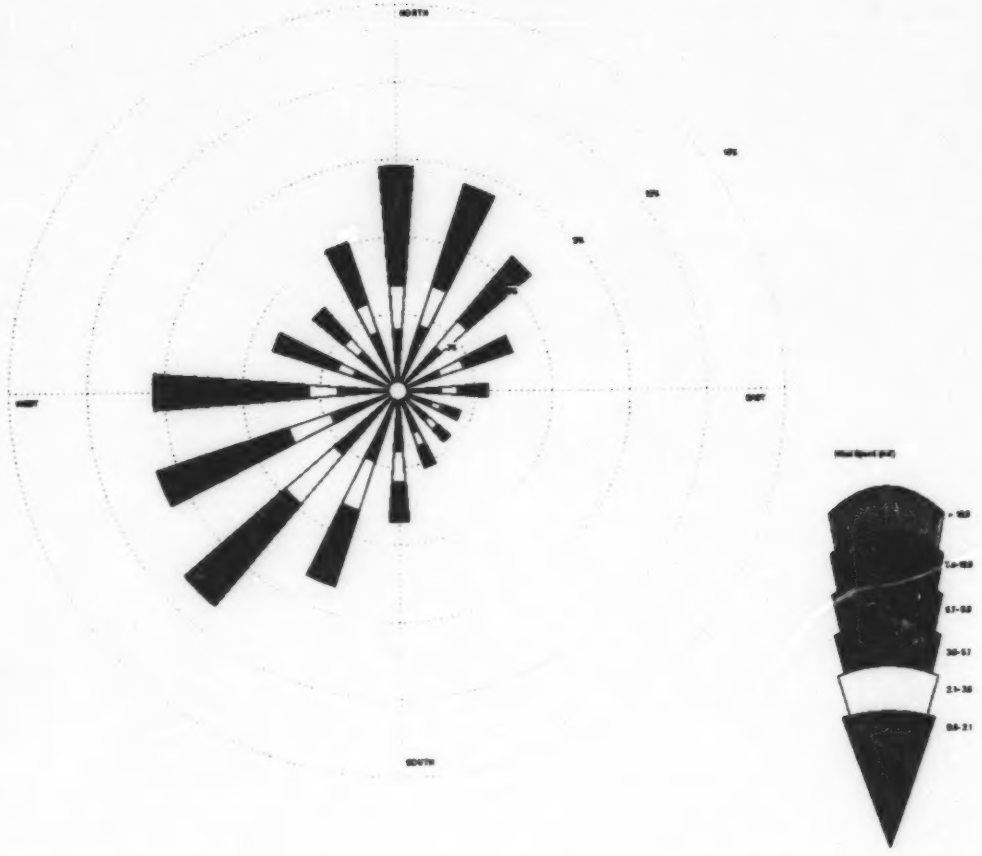

**Figure 5.18 Wind Rose for the Peace River Northwest Boreal Region AERMET Meteorology Data Set (1993 to 1997)**

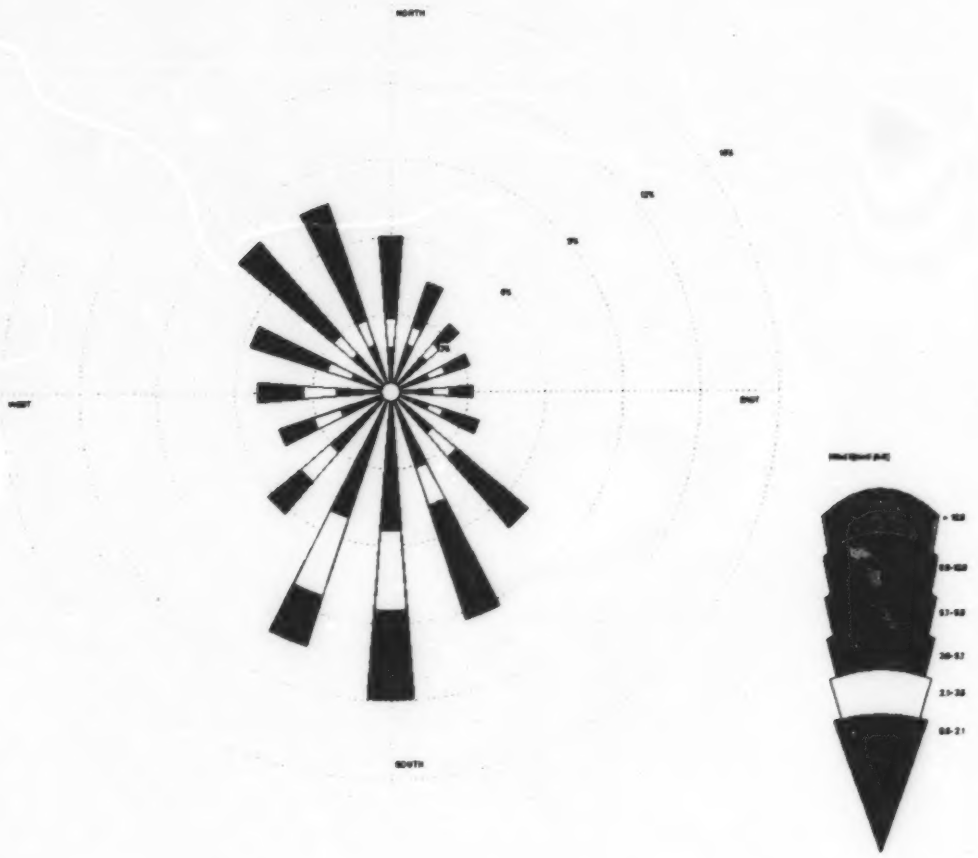

**Figure 5.19 Wind Rose for the Red Deer Parkland Region AERMET Meteorology Data Set (1993 to 1997)**

## 6.0 REFERENCES


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